DOCUMENT RESUME

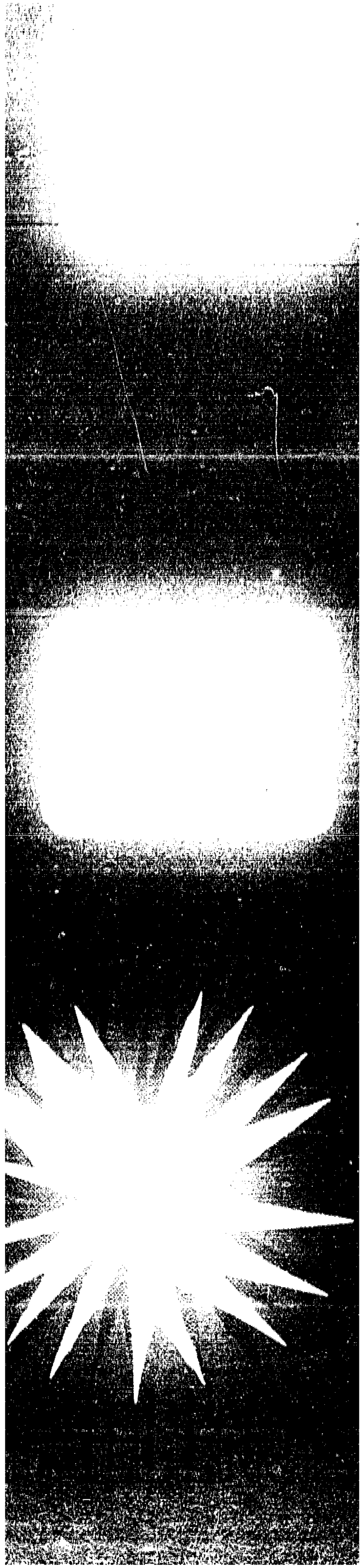
ED 133 228 | SE 021 903

AUTHOR: Angis, Lynne; And Others
TITLE: Priority One: Environment. The Energy Challenge.
INSTITUTION: Union Township Board of Education, N.J.
SPONS AGENCY: Bureau of Elementary and Secondary Education (DHEW/OE), Washington, D.C.; New Jersey State Dept. of Education, Trenton. Div. of Research, Planning, and Evaluation.
PUB DATE: [75]
NOTE: 40p.; For related documents, see SE 021 898-906; Not available in hard copy due to copyright restrictions

EDRS PRICE: MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS: *Energy; *Environment; Environmental Education; *Instructional Materials; *Natural Resources; *Secondary Education; *Units of Study (Subject Fields); Wastes
IDENTIFIERS: Elementary Secondary Education Act Title III; ESEA Title III

ABSTRACT

This unit is one of a series in environmental education for grades 1-12. The unit is designed to be used with secondary school students and includes the following sections: (1) Preface; (2) Foods, Fuels, and You; (3) Blackout in the City; (4) Conservation and Efficiency; (5) Our Present Sources; (6) The Oil Crisis; (7) The Nculear Controversy; (8) Tapping New Resources; (9) Developing Other Ways; and (10) Schedule Sheet for the Unit. References to audiovisual aids, worksheets, and activities are made; these materials are not included with this publication, but may be purchased. These materials have been validated as successful, cost-effective, and exportable by the standards and the guidelines of the U.S. Office of Education. (RH)



PRIORITY ONE environment

POLLUTION CONTROL EDUCATION CENTER
Township of Union Public Schools
Union, New Jersey

THE ENERGY CHALLENGE

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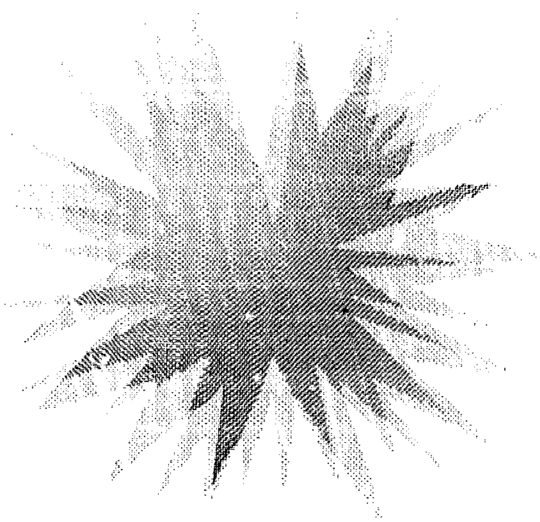
The materials presented herein were prepared pursuant to a Grant from the New Jersey State Department of Education under provisions of the Elementary and Secondary School Act of 1965, Title III.

THE ENERGY CHALLENGE



CONTENTS

PREFACE

The big question is--Can you have the amount of energy that you need and want today for each of your tomorrows? Is the question too big? Let's break it into two parts, then, and you can ask yourself: In my life, why might I need to use more, or less, energy? And, in my life, why might I want to use more, or less energy?

It is the purpose of this Energy study to help you find answers--not for all of the energy problems facing the world today, but for the two questions you have just asked yourself. You can find out, as the days of the unit progress, just where you as an American are in relation to what you have seen and heard about the energy crisis.

The word *crisis* means *crossroads or turning point*. Crisis in time of illness, for example, can mean that someone is between life and death. The turning point could go either way. Some people feel that our energy problems are serious enough to be life and death matters. Whether this is true or not remains to be seen. We do know as Americans that we are at a turning point which we have called the energy crisis.

Shortages of food or fuel have occurred throughout human history on our planet. Shortages exist today, all over the world. However, as American consumers, we are not comforted by thoughts that the energy crisis in our country is sadly similar either to a past or a present crisis elsewhere. We are encouraged, rather, by positive action—as well as by positive thoughts that we can solve the energy crisis. Therefore, we want to know what our choices are in this time of crisis, so we can make the correct decisions.

We have to know if we can change the connections that exist between our styles of daily life and our growing demands for more energy. Will we freely choose smaller cars and mass transit, building designs that economize heat and light, and--if it is costly--recycling of all possible resources?

We have to know if our environment will be spoiled as we supply more and more energy to our population. Will we, or our descendants, have to live with air and water pollution and with radioactive wastes in order to satisfy the energy demand?

We have to know if the United States can continue to be the biggest energy consumer on the international scene. Are we and developing nations around the world going to be in real competition to get and use the world's energy resources?

And, finally, we have to know if each energy resource that we are now using can be more or less helpful to us in the future. Which old and which new resources can we safely develop, and how much of a job can each one do for us?

Answers to small questions you can get as you move into the story of energy today. But remember, the main character of the story is you. The big question, of needs and wants, is for you to understand and answer.

FOODS, FUELS, AND YOU

Learning The Energy Language

This thing called energy is everything. And yet, did an expression like "the world's total supply of energy" ever cause you to wonder what was meant? Have you thought that "stored energy," often called "fossil fuel," is similar to the food you eat? No? You wouldn't choose a dish of coal for supper, though coal is known to be an energy source. To you, coal is a fuel, not a food.

Foods And Fuels: How Are They Similar?

The foods you eat and the fossil fuels—coal, oil, and natural gas—all got started with energy from the sun. The sun delivers daily, to each acre of our country, about 20 million kilocalories. Since a kilocalorie is 1000 calories, we get a lot of solar energy every day! Some of this daily energy becomes the plants and proteins that you eat. Millions of years ago, solar energy produced the fossil fuels that are used today. It would take this long for more fossil fuels to be produced.

Because you need food and fuel in order to survive, you are called a "consumer." A consumer, simply, is an energy-user. At last count, by the way, one of the three billion human energy-users on this planet was you!

Have you ever thought that plants, birds, fish, and other animals on our planet use only food? The use of fuel as well as food is something only humans do. First, let's consider how you use food.

Your body is warm, and you are able to move it. Both of these descriptions fit you, warmth and activity, because of the food you consume. Heat is given off as the food you eat combines in your body with oxygen. The cells of your body act like trillions of combustion engines. Energy input—in the form of food—lets you think, laugh, play, and even dream. All of your body's activities, whether you are asleep or awake, add up to your energy output.

Foods And Fuels: How Are They Different?

To a human being, the difference between food and fuel is how the energy is released, in what form it is released, and what it is used for.

All matter is made of tiny particles called atoms. Atoms may be bunched together into molecules. The atoms in a molecule are held together by chemical bonds. Chemical bonds can be thought of as energy, chemical energy. Energy can be released when chemical bonds are broken or rearranged.

Fuel Coal, natural gas, wood, and oil are made of molecules which in turn are bunches of atoms of hydrogen and carbon. The energy in coal, gas, etc. is in the chemical bonds between these atoms. Oxygen has the ability to break and rearrange these bonds and to release the energy, but oxygen needs a little push to get started. It needs a little heat energy to break the first few chemical bonds. When they break, they release more than enough energy to cause the oxygen to break more bonds which release more energy. As long as fuel (coal, gas, etc.) and oxygen are added, the reaction will continue. This reaction is called *oxidation*. Oxidation changes chemical energy mostly to heat energy with a little light energy. We use the heat energy to keep warm, cook food, move the pistons in an automobile, or it is changed into electric energy for many other uses. The light energy, for the most part, is not used.

Fuel for your body is called food, and the chemical energy is released in a different way, in a different form, and for a different purpose.

Food Sugar, starch, and fat are made of molecules which in turn are bunches of atoms of hydrogen, carbon, and oxygen. The energy in these foods is in the chemical bonds which hold the atoms together. Oxygen is still needed to release this energy, but oxidation is too violent. It releases the energy too fast for your body. Oxidation also releases most of the energy in the wrong form.

The slow release of energy from food in your cells is called *respiration*. In respiration, not only is the chemical energy released slowly, but most of it is turned right back into chemical energy. The energy in food is transferred into molecular jars and stored for later. This is why you need only eat three times a day even though your body requires energy all the time. Also, you don't need oxygen to get the use of the energy in the molecular jars.

Once in the jars, this energy is circulated through your cells and used for growth, repair work, and release of more energy from your food.

Not all of the energy from respiration goes into storage. Some is released as heat energy which is why your body temperature is normally 98.6°F.

Energy Values	Calories Per Pound
Fuel (coal)	2,500,000–3,500,000
Food	
sugar & starch	5,000
fat	9,000

There appears to be a large difference between the amounts of energy in fuel and food, but remember, calories are a measurement of heat energy. Most of chemical energy released from fuel during oxidation comes off as heat energy, and most of the chemical energy released from food during respiration stays as chemical energy in the molecular jars.

Blackout In The City!

Record Heat Wave Continues

Record-high temperatures have hit this city for five straight days so far. Some areas of the city have been without electric power since the third day of the heat wave. Angry citizens are demanding explanations for the power shortage from the officials of Consolidated Power. They are shocked at the explanations they get. It seems that Number 3 fuel oil, which the company uses to run its generators, is in short supply. Officials explain that the heat wave came at a very bad time for the power company, which is in the process of converting its generators from Number 3 fuel oil to high-sulphur coal. The burning of coal is now legal in our city due to the fuel-oil shortage. For years, coal burning has been prohibited in order to meet the standards set by the Clean Air Act of 1970.

Power Cutbacks Explained

Consolidated Power and Light reports that power production had been cut back as much as 15 percent even before the heat wave. In answer to numerous complaints, power officials seem only to be saying, "Sorry, but our hands are tied!" Increased demands for electric power during this heat wave, they say, caused a series of overloads and burned-out switches. Time is needed to repair or replace the worn-out transmission equipment. However, the officials promise a speedy end to the blackout. They say that power will be turned on in the business district at midnight tonight. But this news is not much comfort to the homes and small businesses that will probably be without power for another day.

Power Failure Paralyzes City!

The blackout is expanding. More of the city joins the areas without power during the worst heat wave we have had. There is hope that the heat wave, now in its eighth day, will soon let up. However, citizens are not so hopeful about Consolidated Power.

Promises to the business district that electricity would be restored at midnight have not been kept. Some of the city's homeowners and small businessmen have been stranded without electricity for five days. Industrial production has all but stopped, the gasoline pumps are off, and talk grows that the mayor must declare a state of emergency.

Mayor Makes Plans

The mayor's office announced that the city council plans to have power turned on in the city's main districts on a rotating six-hour schedule. No one area will be without electricity for more than twelve hours. The mayor also asked that citizens limit their use of electricity while they have power. Large air conditioners in shopping centers, theaters, schools, and government buildings must be shut off.

A temporary curfew at dark will be used. This will help police in areas without power because burglar alarms and street lights will not be working.

The food industry has been hit hard by the blackout. Without refrigeration, great amounts of food are spoiling.

Gasoline stations have shut down, except those which had put in hand pumps during the last blackout in February. Some people are using city buses, but many people are staying home from work. Schools are closed.

Hospitals, police stations, water companies, radio stations, and newspapers have been running on their own emergency generators. There have been great losses in many industries because assembly lines were halted. Union leaders and the companies' officials are involved in talks about loss of pay.

A special mayor's committee has been set up to find ways to avoid such problems in the future.

CONSERVATION & EFFICIENCY

How Much Power Do We Really Need?

We are the biggest energy consumers in the world. Until now, energy has generally been cheap and abundant for us. We have used it freely to maintain a high standard of living. All of our planners have predicted that more and more energy would be consumed to support our growing economy.

But now things have changed. Fuel bills are rising. Gasoline supplies are limited. Public officials ask us to turn off our air conditioners to avoid blackouts and brownouts. Energy is no longer cheap and no longer abundant.

How should we act in this new situation? Can we find ways to expand our energy supplies and meet our growing demands? Or should we try to use less energy? Environmentalists warn us of the increasing harm to our environment as more and more energy is consumed. Should we change the way we live?

Conserve Energy And Cut Waste

Are you willing to do without cars, hi-fi stereos, TVs, and air conditioners? Most people are not. These drastic measures can cut down our energy demands, but there are other ways too. We can conserve energy in ways that are acceptable to us, and we can use energy more efficiently. Did you know that the Federal Office of Emergency Preparedness has estimated that up to 25 percent of the energy we now use is wasted unnecessarily? Other sources predict even greater savings if wise energy use becomes everyone's practice.

How Is Energy Wasted?

Whenever we convert the energy stored in fuel into a useful form, some of the energy is wasted. For example, when wood or coal is burned in an open fireplace, less than 20 percent of the energy is radiated into the room. The rest escapes up the chimney. A more efficient heating system is a well-designed home furnace. It can capture up to 75 percent of the energy in the fuel and make it available for space heating. The energy efficiency of various devices is given on the chart. Energy efficiency is defined as the percentage of input energy which is converted into a useful form. Although technology limits the efficiency of any one device, we can find many ways to improve the overall efficiency of our energy use.

Saving Energy In Industry

Improve the efficiency of electric-power generation. The average fossil-fuel electric-power plant is only 33 percent efficient. In other words, two-thirds of the fuel energy we use to generate electric power ends up as waste heat in the environment. The most modern power plants are 40 percent efficient. And scientists are working on new methods of conversion which may raise this figure to 50 percent. Meanwhile, modernization of older plants will mean significant energy savings.

Make waste heat useful at a "total energy" plant. Some industrial and commercial plants are generating electric power on site. The resulting waste heat is recovered as steam and it is used to heat buildings, to power machinery, and to carry on industrial processing. The overall efficiency of a "total energy" plant may be from 75 to 85 percent.

Recover, recycle, and reuse steel, aluminum, and paper products. The paper and metals industries are th largest industrial users of electric power. And of all the metals, aluminum requires the most electricity to produce. In throwing away tons and tons of these products each day, we not only waste valuable materials and pollute the environment—we also waste energy. The National Commission on Materials Policy estimates that 2 percent of our total energy demand could be saved by recycling available steel, aluminum, and paper. It takes less energy to produce these products from scrap than it does to make them from raw materials.

Saving Energy In Transportation

Design and use cars with energy efficiency in mind. The largest share of a family's energy budget—over half the dollars spent for energy—go to run the family car. Car pools, smaller cars with fewer electrical features, and better car maintenance will help to save both energy and dollars.

Increase use of mass transit in urban areas. Buses are four times more efficient than cars. And commuter trains are even more efficient. Increased use of public transportation in urban areas will cut down on energy use. It will reduce air pollution and traffic problems too.

Shift intercity travel from air to ground transportation. Air travel is fast and convenient, but it also consumes the most energy per passenger mile. Buses, trains, and even passenger cars are a more energy-efficient means of traveling from city to city.

Shift freight transport from highway to rail. In recent years, the trucking industry has grown, while the railroads have suffered great losses. But trucks use up to four times more energy to haul freight than railroads use. A trend back to rail transport will save energy.

Saving Energy In The Home And In Offices

Improve the design of commercial buildings. Many new office buildings use more energy than they must for heating and cooling. Windows do not open, so air conditioning is necessary even when outside temperatures are pleasant. The entire building may have to be heated, cooled, and illuminated in off-hours even though only one room in the building may be in use. Many buildings are poorly insulated and poorly located. They do not take into account the effects of sun and wind on heating and cooling.

Improve insulation of homes. Stopping air leaks around doors and windows can decrease a family's heating bill by 15 to 30 percent. Proper insulation of walls and ceilings and the installation of storm windows will also save large amounts of energy otherwise wasted.

Provide better maintenance of heating systems. Heating a home is the largest expense after the family car in a family's dollar-and-energy budget. Better maintenance of heating systems can reduce fuel bills by 10 percent.

Purchase efficient appliances and lighting fixtures and use them wisely. Do you leave the lights on when you leave a room? Is the air conditioner in your home the most efficient model available? Do you know that an instant-on television uses up electric power even when it is turned off? Electric power can be saved by buying efficient appliances and using them only when necessary. Use the activity cards provided in this unit to investigate appliances in your home.

Conservation Can't Do It All

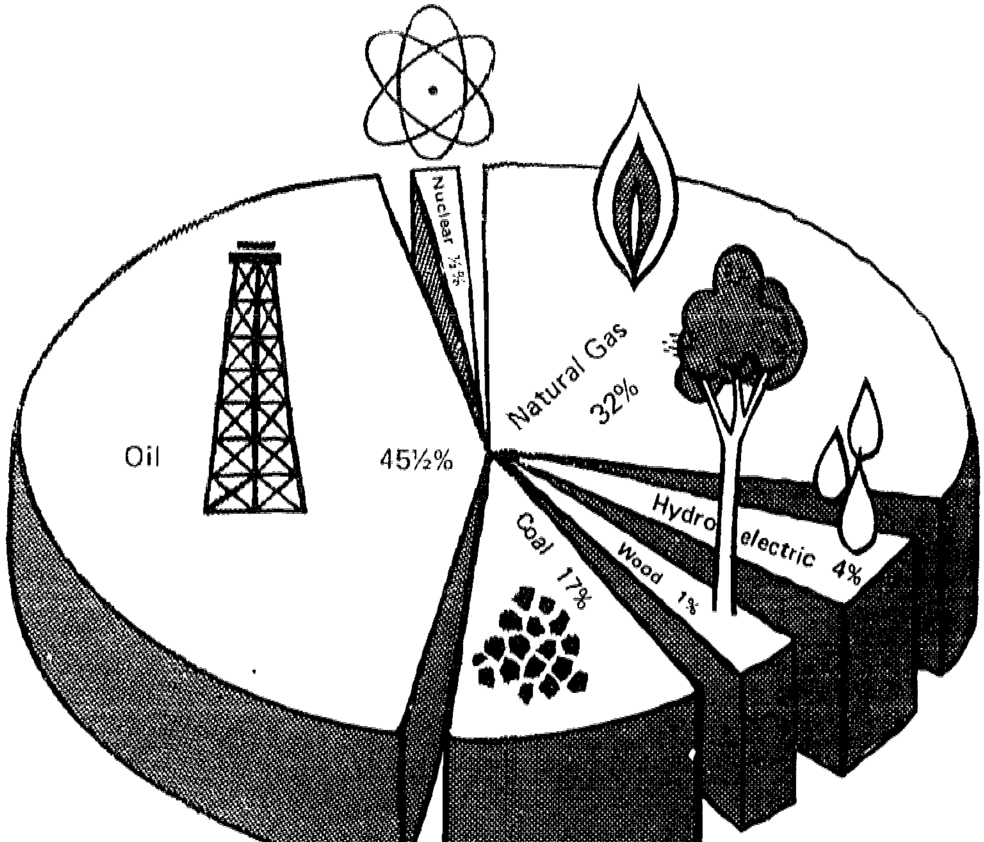
Wise energy use can cut down energy demand by 25 percent or more. But some of the measures suggested will take time to carry out. In the meantime, we may continue to suffer energy shortages.

As we look to the future, we must also consider the supply problem. Conservation measures can slow the growth of energy demand but not stop it. The basic pattern of increasing energy use will continue if we choose to maintain our current life-style and our growing economy. The remaining sections of this booklet are concerned with problems of energy supply, both present and future.

OUR PRESENT SOURCES

What is the picture of energy supply in our country? The 1973 Energy Pie gives you a quick look into our recent past. Which two energy sources supplied more than 75 percent of the total energy we consumed in 1973? Which of these sources was imported in large quantities from foreign countries? Which sources on the graph are a very small part of the total energy picture?

In the next few pages, you will find information about the four sources that have supplied most of our country's energy needs for a long time. Two types of information are presented for each energy source: opinion and fact. The "opinions" represent the type of statements producers and consumers are making today. As you read each "opinion," ask yourself: What point of view is presented? Whose view is it? Is it based on enough fact? Then read the facts and judge for yourself. Since each "fact" section is brief, you may want to do additional research at the library. Can you judge from the facts how today's chief sources of energy might appear on an Energy Pie of the future?



THE 1973 ENERGY PIE

HYDROELECTRICITY

An Opinion

American conservationists and people who enjoy fishing are joining together now as never before against the Federal Power Commission. The commission's plan for developing the Missouri Basin to obtain electricity has already caused great alarm. Licensing procedures for the commission's power dam network have stopped, and congressional hearings have begun.

Does it concern you? Water power projects kill so many eggs, larva, and small fish that all fishing in the area suffers as a result.

Do you care? Damming up rivers and destroying streams are far reaching dangers to the environment.

Contact us for further information and possible membership in the

National Committee for the
Preservation of the Missouri Basin
Isaac Waltham, Chairman
Anglers Association of America

Hydroelectric Power — The Facts

Making use of moving water is not new to mankind. Long ago, people made wheels and put them into fast-flowing streams and rivers. The power from the turning wheels was used to grind grain and pump water for irrigation. In the United States, many of the first factories were located on or near water. Water wheels powered growing industries here such as the textile industry.

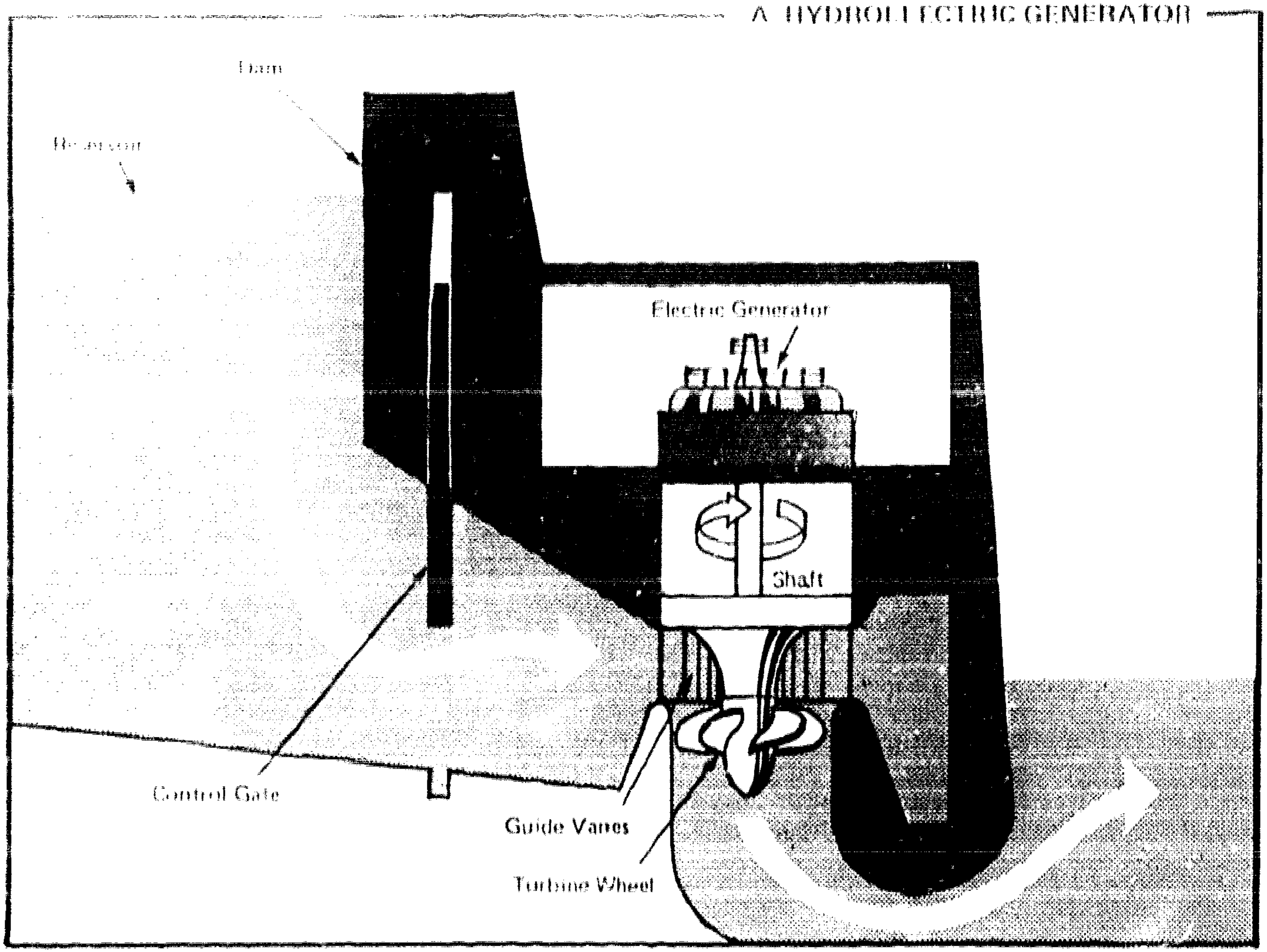
The technology of water power improved with the development of the turbine. Its curved blades made it a more efficient energy-gathering device than the water wheel. Turbines are now used in many industries to convert steam energy into useful work.

In hydroelectric plants, the power of falling water drives turbines for the production of electric power. One of the first such plants in the United States began operating at Niagara Falls, New York, in 1896. Today, the water power from Niagara Falls is still a reliable producer of electricity. However, the United States contains few natural waterfalls. Most of our hydroelectric power comes from man-made dams such as the Grand Coulee Dam on the Columbia River and the Hoover Dam on the Colorado River. Construction of these dams and reservoirs has a number of benefits. For example, the network of dams in the Missouri River Basin provides for flood control, irrigation, and recreation as well as electric power.

In many ways, water power is a very desirable energy source. Fossil fuels are used up when they are burned, producing waste heat and poisonous gases as well as useful power. Water power is not. Falling water provides a continuous, clean source of energy. And, once the dam and the power plant are built, hydroelectricity is relatively cheap to produce.

Can more hydroelectricity be made to run our industries and light our homes? Today, it furnishes less that 5 percent of the total energy used annually in the United States. If the resources we do

A HYDROELECTRIC GENERATOR



have were fully developed, water power could provide 8 to 10 percent of our country's total energy demand in the 1980s. But this percentage would decrease again as the total energy demand continued to rise.

Several other factors tend to limit further development of water power. The largest potential resources for water power are the rivers of the Western United States. East of the Mississippi River, power demands are greatest. Water power resources there have been developed almost to capacity. Of course, electric power can be transmitted over a distance. But transmission lines are expensive and power losses increase with distance. Therefore, with present technology, power transmission over great distances is not economical.

Environmental effects must also be weighed. It is necessary to flood thousands of acres to erect a dam and reservoir. We have learned, sometimes too late, that this can change the ecological balance of an area for hundreds of miles up the river. Changing the flow of water by damming it up changes the chemical and mineral content of both the water and the nearby soil. Thus, food chains can be disrupted or destroyed. Also, earth tremors can occur when large dams create new lakes which are too heavy for the layers of rock beneath them.

Should we develop water power resources to meet from 8 to 10 percent of our total energy demands? To answer this question, we must know about the costs. The cost to the consumer, which is measured in dollars, is known. The cost to the environment, which cannot be measured in dollars, is still largely unknown.

An Opinion

Old King Coal is the answer to America's energy shortage. Today at our pilot plant in Green Hills, Oklahoma, we are testing processes that we have developed. These processes turn high-sulfur coal into clean-burning synthetic gas.

Until now, some commercial plants did gasify small amounts of coal—at rather high cost to the home and industrial user. However, we are now ready to produce a synthetic gas in large quantities. We think that this gas will be both plentiful and cheap.

About eight years from now, we project, our newly constructed plants will be the Midwest's major suppliers of synthetic gas.

J. P. Collier, Manager
Fuel Research Division
Midwest Coal Corporation

Coal — The Facts

Coal lost the energy race to natural gas and petroleum in our country about 25 years ago. From that time until just recently, natural gas and petroleum have been cheaper to get and easier to use. In 1900, coal supplied 70 percent of the United States' total energy demand. By the early seventies, this figure was down to 18 percent.

North America has the most valuable coal fields in the world, both in quantity and quality. Coal is one of the top natural resources of the United States. Formed by natural processes in the earth, this fossil fuel is the remains of plant life that lived millions of years ago. Of the 3 trillion tons of coal in the United States, 390 billion tons can be mined now. This would be enough to last a few hundred years at the current rate of use!

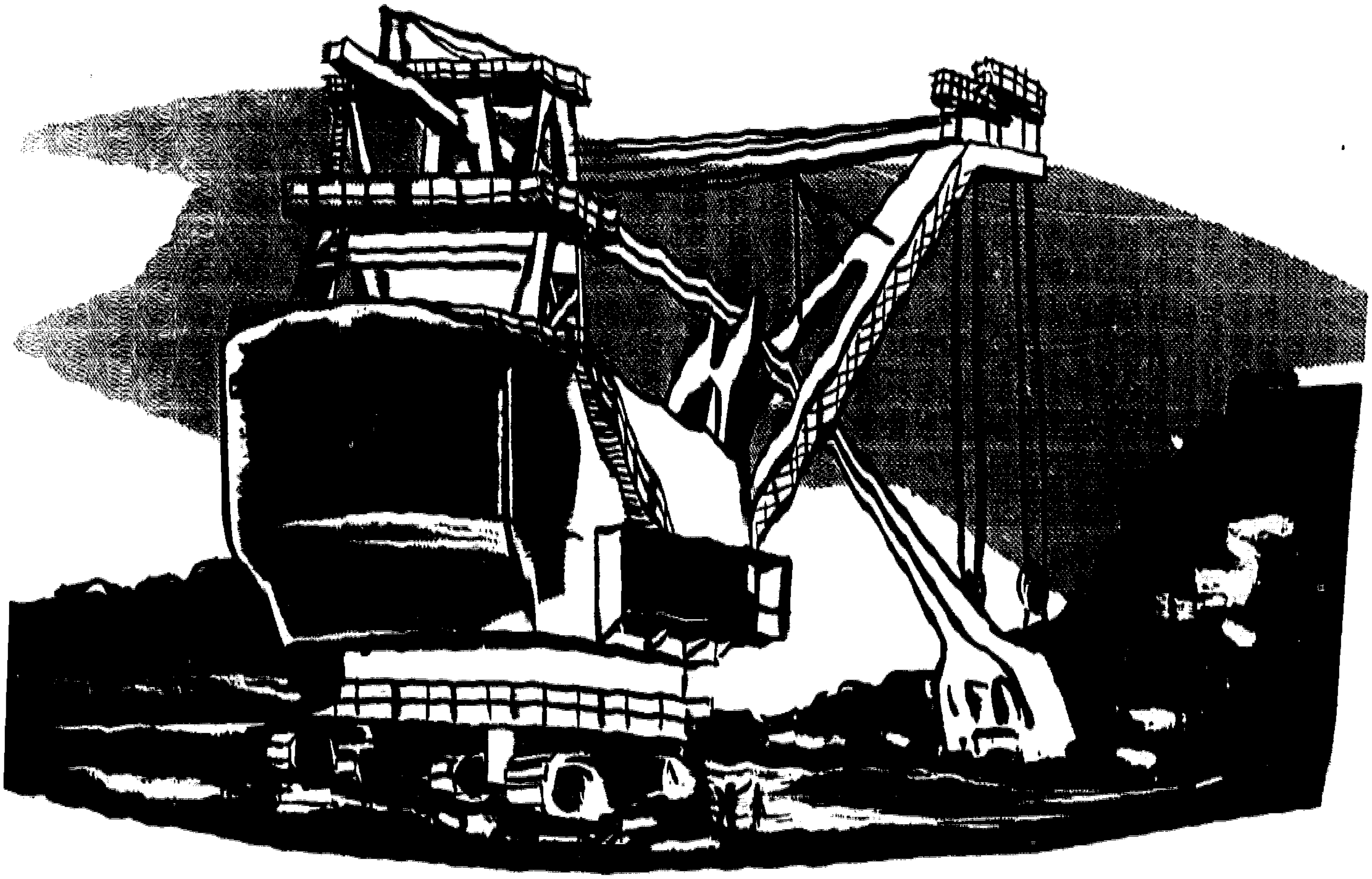
Why has this valuable resource played a smaller and smaller part in our country's energy story? One reason is that foreign oil was once cheap and available to us. Also, natural-gas supplies within our country were cheap and abundant. Therefore, improving the technology of underground mining and of processing coal never got the attention it deserved.

It is a difficult job to mine coal from deep underground mines. It is a dirty and unhealthy job. In the United States today, there are almost fifty thousand coal miners who are ill with black-lung disease. The "Coal Mine Health and Safety Act" was designed to protect the workers in the coal fields. But the new standards caused hundreds of mines to close down, and many small companies were forced out of business.

In the 1960s, coal companies developed the technology of strip mining. This method is cheaper, faster, and safer than underground mining. First, coal seams near the earth's surface are discovered. Then the overburden—vegetation, rock, and soil—covering the seam is removed by power shovels and draglines. Huge machines like the "Gem of Egypt" and "Big Muskie" can scoop up over 100 cubic meters of earth with a single bite! Tearing up the land as they go, these giant monsters destroy whole environments to get at the coal beneath.

Although only 3 percent of all our coal resources can be obtained by strip mining, coal companies are relying on this method more and more. Half of all the coal that was mined in the

1960s was strip-mined. And plans are now in progress to strip-mine the rich supplies of low-sulfur coal located in the Western states. Our undeveloped technology for underground mining and our concern for the safety and health of miners explain this fact. However, the pros and cons of strip mining have reached the halls of Congress. Many people feel that strip mining causes permanent damage to the environment. This is believed even if the coal producers, at their own expense, attempt to restore the land.



Another environmental issue is air pollution. Coal is a dirty fuel. Sulfur dioxide, one of the most serious air pollutants, is produced in great amounts when coal is burned. The Clean Air Amendments of 1970 caused a sharp decline in the use of coal for electric-power production. (This is the biggest use to which we put coal.) In many areas, the burning of coal was made illegal. Some utilities and industries using coal have found it too expensive to reduce the sulfur dioxide coming from their smokestacks. They have switched to the use of oil or gas instead. In fact, for the first time in almost a hundred years, no coal is being burned in New York City to produce electricity.

Can coal get back into the energy race? Should it be allowed to? Some people today are willing to reduce air pollution standards in favor of using high-sulfur coal. Others are not willing to allow hard-won environmental victories to be lost again.

Many scientists today are trying to return coal to the energy race. They are able to change coal into clean-burning liquid and gaseous fuels. These, they predict, will one day replace petroleum and natural gas. Two government agencies, the Bureau of Mines and the Office of Coal Research, are now working with industry to produce man-made gas and oil from coal. In one experiment, coal is being gasified underground at the coalbed itself. If successful, products like HYGAS, BI-GAS, and SYNTHANE may become part of our economy. The trouble is, nobody is quite sure how long it will take and how much money will be needed to make these products. Some planners say that with a $9 billion investment, man-made gas from coal will supply 10 percent of our demands for gaseous fuels in the 1980s.

NATURAL GAS

An Opinion

We had you, the consumer, in mind when:

We spent $180 million for the successful explorations in Appalachia that led to our discovery of new gas reserves. We at Consolidated Gas are happy to report our recent discovery, since it helps us to supply your needs for the clean, efficient fuel—natural gas.

We estimate that this latest discovery, a big one, could be enough to fuel the entire United States with natural gas for almost two years!

The future of natural gas will be bright indeed as we tap the limitless supplies beneath the ocean floors and mountain slopes. But you, the consumer, must be willing to share with us the increased costs of production. Only then can we continue to serve your needs.

Hubert A. Merland
Public Relations Division
Middle State Consolidated Gas

Natural Gas – The Facts

The fuel called natural gas is a fossil fuel composed chiefly of methane gas. Like petroleum, natural gas was formed from marine organisms that lived billions of years ago. It is often found with oil deposits. It was either trapped on top of them or dissolved in the oil itself. However, gas reserves also exist far from oil fields.

Use of natural gas began in the 1930s when techniques were developed to pump, store, and transport this fuel. Pipelines were made to carry huge volumes of natural gas to distant users. Huge amounts are needed because 100 cubic feet of gas must be burned to get the same energy that 1 gallon of gasoline gives. Today, the nation is covered by a network of gas pipelines almost a million miles long! These pipelines start at the gas wells. Most of these wells are located in Texas, Oklahoma, California, Louisiana, and West Virginia.

The United States is, by far, the largest producer and user of natural gas in the world. Does your family cook with natural gas? Over half the families in our country do. In fact, about 25 percent of our natural gas is used in the home for heating and cooking. Forty percent is used to make electric power. Natural gas is also a source of petrochemicals. These are used for the manufacture of products such as drugs, detergents, fertilizers, paints, plastics, synthetic rubber, and synthetic fibers.

Gas is the simplest of all fuels to burn. A gas furnace usually needs less care and upkeep than a furnace which burns coal or oil. It is also the cleanest-burning fossil fuel. Natural gas produces far less air pollution than coal, gasoline, or oil.

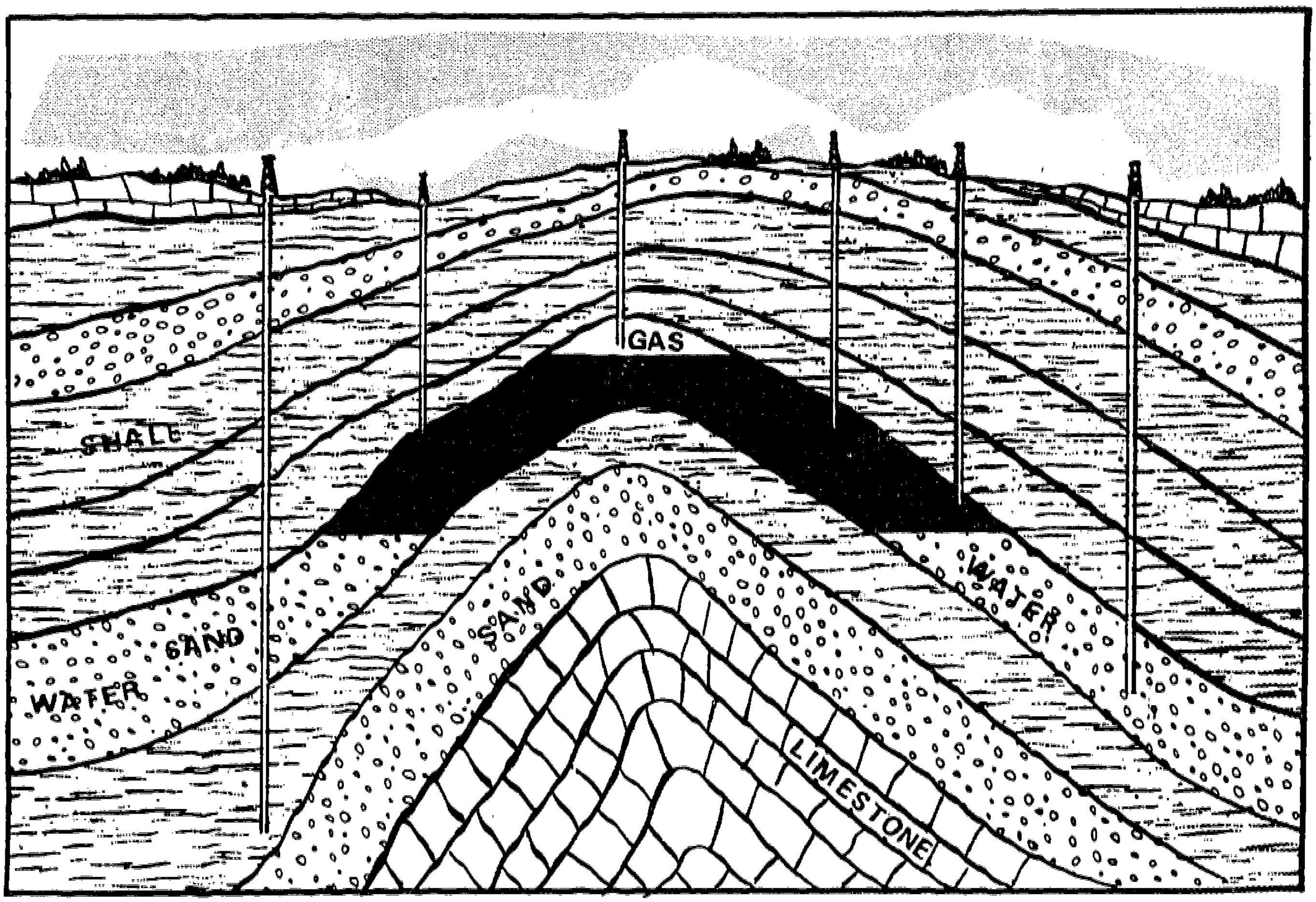
The demand for and the use of this energy resource is skyrocketing. In the United States, for example, in 1947 natural gas supplied 14 percent of our total energy needs. In 1973, 33 percent or one-third of our total energy came from natural gas.

A big reason for the increase in the use of natural gas is its low cost. In 1954, the United States government put a ceiling—meaning a price limit—on the cost of natural gas to the consumer. From 1954 until recently, attempts to find more natural-gas reserves became fewer. Can you guess why? The gas companies said that new reserves had become more difficult and more expensive to find. Therefore, exploring and drilling for new gas reserves could cost a producer more than he might get back from the sale of the gas. With the price ceiling fixed, known reserves were used up faster than new supplies were discovered.

In 1973, known underground gas reserves totaled 291 trillion cubic feet. The American consumer used 22 trillion cubic feet. Therefore, we know that we will run out of natural gas. The only question is: when?

In late 1973, the gas companies estimated that their known reserves would last no more than five years. In some states today, new customers for natural gas are being turned away by utility companies. We know that the demand for natural gas is increasing. The supply—whether known or as yet undiscovered—is decreasing. However, some scientists estimate that the amount of undiscovered natural gas in our country could turn out to be enough to power our homes and industries until a little after the year 2000!

Our future reliance on natural gas depends on how we answer these questions now: What is the true extent of our natural-gas reserves? How fast can we risk using them up? What price should the users of the gas reserves have to pay? Should we continue using this valuable fuel for electric-power generation when other more abundant fuels will serve as well? Or should we save it for use in homes and in the chemical industry? (See the articles on coal and wastes for information on man-made gas fuels.)



An Opinion

Do the oil companies own the United States?

The oil companies have hauled off huge profits by oil depletion allowances and tax exemptions. They have influenced the price of competitive fuels.

The oil companies have hidden basic information on oil reserves and supplies.

The oil companies have fought proposals to develop mass transit systems, despite the fact that mass transit would help to conserve gasoline.

In 1971, when United States oil production stopped rising, did the oil companies help to prepare us for using less and less oil? No! It is the opinion of this writer that we were due for an oil crisis with or without Mideast oil. And what are the oil companies doing today? Buying up stocks and shares and controlling interests in every imaginable alternate fuel! I repeat: Do the oil companies own the United States?

They do.

Leander Hero
Editorial Staff of the Sunday Star,
Hometown's Record of the News

Oil – The Facts

Did you know that you can run a car and heat a home today because life forms existed billions of years ago? You can walk on leatherlike shoe soles, put a record on a record player, pick up a pencil and doodle, and listen to the music all because life forms existed so very long ago. Gasoline, oil, clothing materials, records, and pencil lead (graphite) all have the same ancient history behind them!

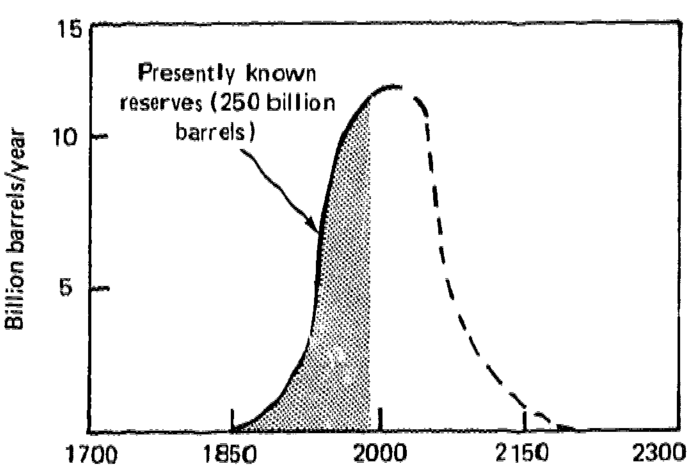
Billions of years ago, the land surface of our planet was covered by shallow seas. Even then, the one-celled creatures we call plankton lived in these waters. Their remains settled to the bottom of the ancient seas and were covered by other sediment. The material underwent changes and, over millions of years, collected as petroleum in scattered subsurface pools. Petroleum, a highly prized substance, is also called crude oil. It is piped up to the earth's surface and stored in huge tanks or piped to refineries. When crude oil is refined or processed, it becomes many things as the chart shows you. Notice how much oil we refine into gasoline for our transportation purposes. So much petroleum is used in the United States today that it amounts to almost half of all the energy that we use.

Products	Percent of Oil	Uses
Gasoline	41.3	Motor fuel, solvents.
Kerosene	4.7	Range fuel, Illuminant, motor fuel.
Gas oil, distillate	14.5	Domestic fuel, Diesel fuel
Other fuel oils	25.3	Heavy fuels, Diesel fuel, gas oils.
Still gas	6.0	Refinery fuel.
Lubricants	2.4	Heavy and light oils and greases.
Asphalt	2.3	Paving, roofing, paints, chemicals.
Coke	0.6	Fuel, graphite, carbon products.
Road oil	0.2	Roads.
Wax	0.2	Candles, sealing, waterproofing.
Losses	0.5	

In the year 1971, the total United States consumption of petroleum was 5.5 billion barrels. From one-fourth to one-third of our oil has come to us in recent years from foreign countries, chiefly from Venezuela and the Middle East. Venezuelan oil is abundant. But it is also so high in sulfur that our present air pollution laws require costly processing of this oil. Until recently, most of our imported oil came from the Middle East.

There are two reasons why we are using more oil each year. First, government tax policies encouraged the oil companies to sell oil from our own country and from foreign countries at low cost to the consumer. With profits kept high by tax benefits, oil companies were able to develop efficient ways of producing, transporting, and marketing oil and oil products from all over the world. Second, as consumers, we grew to depend on oil and its many products, expecting the supply to last forever.

Now we know that oil supplies cannot keep up with our increasing demands. The availability of foreign supplies is uncertain. (See the article on the oil crisis.) Proven oil reserves in our own country amount to 37 billion barrels. This is enough to last us only seven years. (Proven reserves are those that can be produced and marketed under current economic and operating conditions Possible reserves are at least ten times greater.) Efforts are being made to tap new supplies in Alaska and to explore for oil off the Eastern coast of the United States.



Perhaps 200 billion barrels of oil could be obtained from deposits beneath the ocean floor. But objections to offshore drilling have been raised by environmentalists. They believe that the risk of permanent damage to marine life from oil spills far outweighs the short-term benefits of offshore exploration.

We may choose to depend on the world's total oil reserves, rather than rely on domestic reserves alone. But even the world's total supplies will begin to drop off near the year 2000 if oil use continues to grow at the expected rate.

A new source of domestic oil, previously neglected for economic reasons, is now getting considerable attention. This new source is oil shale. Oil shale is a sedimentary rock found in layers beneath the earth's surface. From 25 to 30 gallons of low-sulfur oil can be obtained from a ton of oil shale.

To recover oil from this rock source, the rock must be crushed and cooked at such high temperature that the oil is released as a vapor. The vapor is then condensed into oil.

Proposals have been made to produce oil from oil shale IN-SITU (which means IN THE SAME PLACE). With this method, explosives create a cavity in the underground deposits of oil shale. Natural gas is then pumped into the cavity and fired. This process heats up the surrounding rock and causes the oil to flow out of the rock into the cavity. Finally, the oil is pumped to the surface.

While mining IN-SITU is favored by environmentalists, many developers plan to use conventional stripmining techniques. This will mean the destruction of large land areas in Colorado, Utah, and Wyoming, where most of our oil shale is located. In addition, processing oil shale above ground will create a huge disposal problem. The waste rock will be larger in volume by 12 percent than the original oil shale.

If we choose to develop oil-shale technology, it could add 600 billion barrels of oil to domestic oil supplies. But first we must decide what the future role of oil is going to be in our society.

THE OIL CRISIS

Dateline: 1973 - 1974

Oil production is the biggest industry in the world today. The United States is the biggest consumer of oil in the world. We have 5 percent of the world's known oil reserves. And we are producing—from our own land—about 12 million barrels of crude oil daily. However, we are using almost 17 million barrels each day.

The Oil Scene: 1973 - 1974

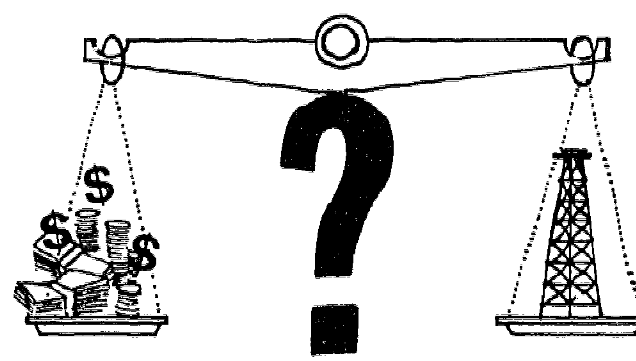
1. Petroleum provides half of all the energy consumed in the United States.
2. Crude oil is needed to keep the present United States economy going.
3. Almost all transportation in the United States is based on oil. And, recent studies show that energy use for transportation purposes is growing in the United States twice as fast as the rate of population growth!
4. One-third of the United States petroleum supply comes from foreign countries, especially from the Arab states of the Middle East.
5. In early 1973, oil shortages are felt in some areas of the country. Domestic oil production is slowing down.
6. Demands for oil are increasing. Planners predict that by 1980 - 1985, the United States will have to import 60 percent of its oil from foreign countries.
7. In late 1973, the United States is faced with a sudden loss of oil supplies from the Middle East.
8. Proven—as well as possible—oil supplies on United States lands cannot last forever, perhaps not past the year 2000.

The Role Of The Oil Companies

The largest American oil companies have international power. They controlled both the production and the refining of foreign oil. Government tax benefits made overseas oil investments very profitable for American oilmen. Domestic oil production and refining slowed down from 1970 to 1973. The oilmen complained that their plans to build new refineries were stopped by environmental restrictions. Other people said that supplies and shortages of oil were planned by American oilmen to increase profits.

How Did The Oil Crisis Happen?

After the Arab-Israeli War of 1973, the Arab states stopped sales of crude oil to all "imperialist" countries. The United States was one of the countries named. The boycott, beginning on December 23, 1973, is the second attempt by Arab states to push their economy forward. They want greater control of oil production in their own countries and greater profits too. The first boycott—during the "Six-Day War" of 1967—was brief, but the price of Mideast oil began to rise. A price of $1.80 per barrel in 1970 became $8.00 or $9.00 per barrel in late 1973. The oil companies made huge profits in 1973 as oil prices rose higher and higher. United States citizens suffered great shortages of gasoline and fuel oil. Early in 1974, the Arab boycott was lifted. Oil supplies increased, but prices remained high, and supplies still fell short of demands.



Arab economy needs as many "imperialist" dollars as it can get!

How heavily should the U. S. lean now and in the future on Mideast oil supplies and at what price are those supplies worthwhile?

Dateline: The Future

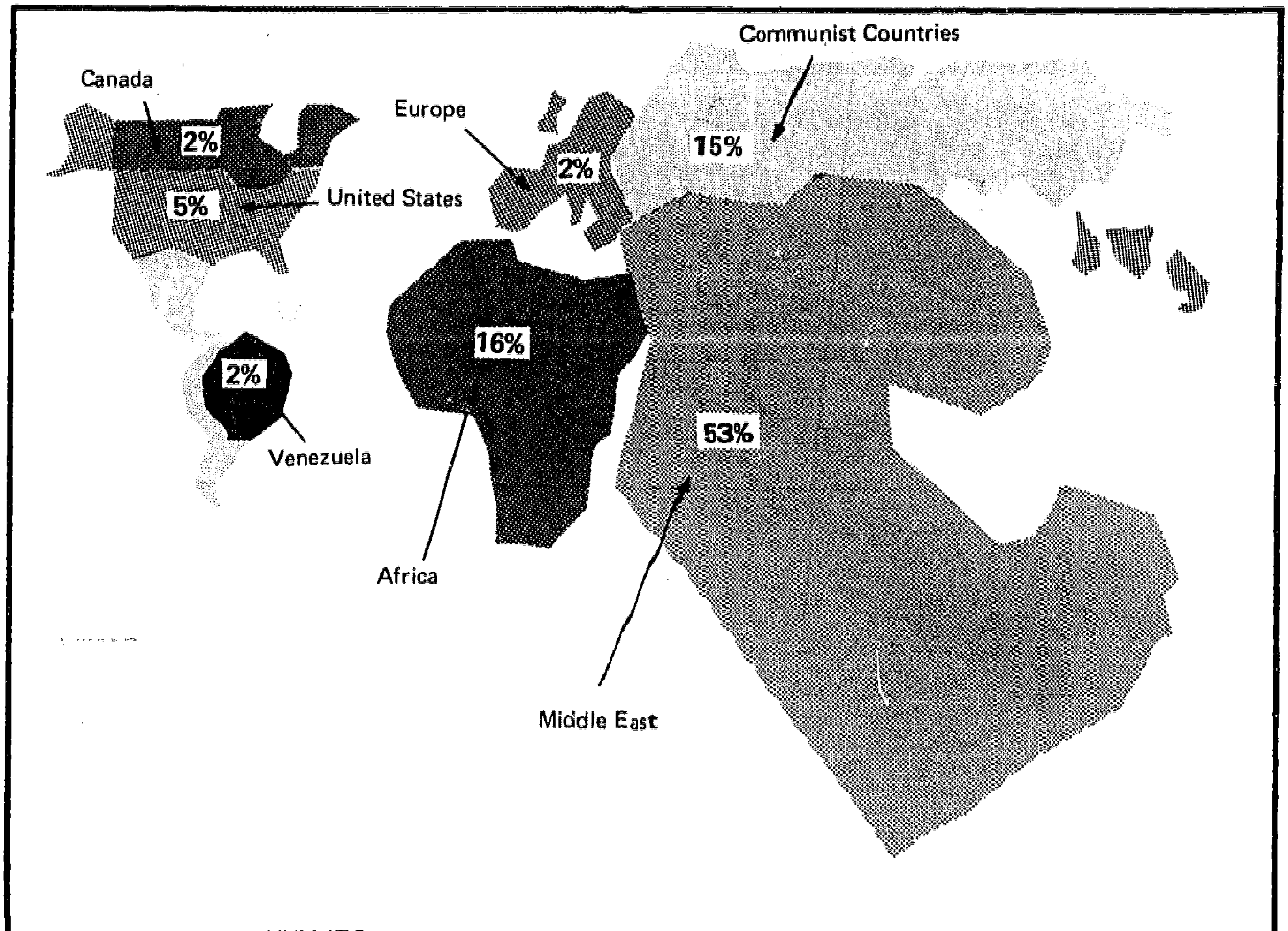
Should we try to keep up the oil scene? Should we remain dependent on foreign supplies? Or should we try to power our economy in other ways? These questions face the United States now. They demand clear thinking and careful planning both for the present and for the future. Much of the planning will revolve around the important questions listed below. Are there other questions that you think might face the energy planners for the future? Do you have some ideas on how the questions should be answered?

1. How long would a changeover from oil to another fossil fuel or to a synthetic fuel take? How long can we afford to wait for changeovers, and do we want to wait?

2. How much foreign oil will be available to the United States in the future? Developing nations around the world want to buy a greater and greater share of the world's oil that is for sale.

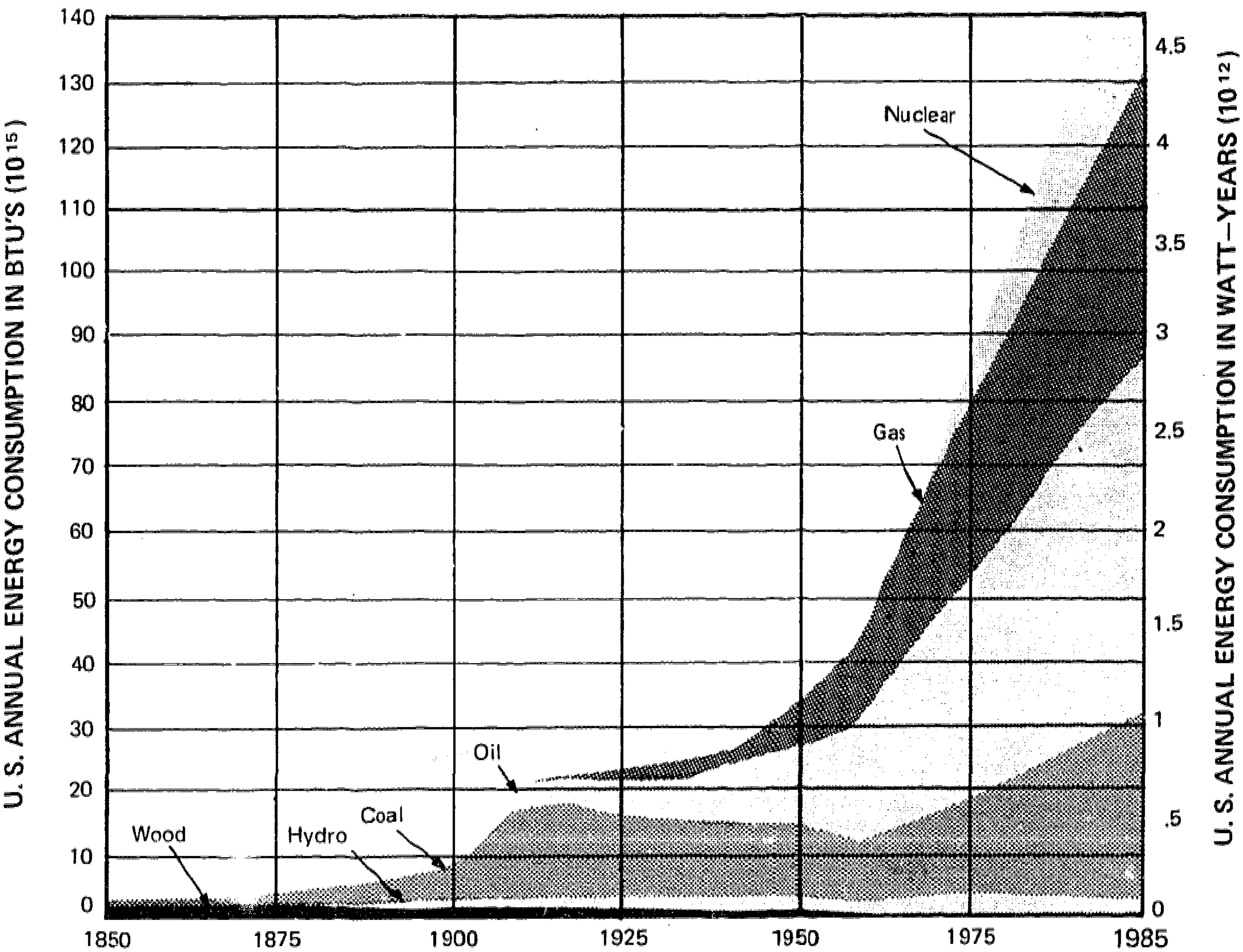
3. Should United States industry develop oil-shale technology? In our country, the costs run high for adventure into alternate fuels. The "returns" for each adventure are still mostly unknown.

4. Suppose foreign oil, once again, becomes cheaper than fuels we produce in our own country. Would we then choose the cheaper oil and forget about the danger of being dependent on other countries?



WORLD OIL RESERVES

THE NUCLEAR CONTROVERSY



United States Energy—A Prediction

Your Analysis

You will want to check out the information that is shown on the graph above. It will help you to answer the questions below:

1. When is the use of natural gas estimated to be at a peak in our country?

2. Is the use of coal expected to increase very much, some, or a little by 1985?

3. Is the use of oil likely to increase by 1985 as much as the graph shows? (To answer this question, you might want to review both the oil and the oil crisis articles in this booklet.) What are the media—newspapers and TV news reports—now saying about oil?

4. Which source is expected to increase the least by 1985?

5. How much energy is uranium (nuclear power) expected to supply by 1985? Is this a large increase over present levels?

6. What are your own reactions to the predictions shown on the graph? Does the future of our "total domestic supply," for example, check out with what you know about our present sources or not?

A Statement For Nuclear Power

Why do we need nuclear energy? Our electricity demands are doubling every ten years. Our reserves of fossil fuels are being used up. They cannot supply our electric demands forever. We need another source of energy—the nuclear source. Nuclear power is available. It is the quickest solution to our energy problems today.

Nuclear power is clean. A nuclear power plant does not pollute the air with soot, smoke, or fumes. And it is safe. A nuclear plant is built only after long investigations into health and safety matters have been made. Then a license to build is granted, and the construction is supervised. Also, all radioactive wastes produced by a nuclear plant are carefully disposed of according to rules set down by the Atomic Energy Commission. In short, a nuclear power plant is a good neighbor—clean, quiet, and helpful.

A Statement Against Nuclear Power

Do you know the danger in store for you if you accept the soft-sell on nuclear power without getting all the facts? Suppose you were told that millions of families could now have all the cheap electricity they want through nuclear fission—and that only one ounce of radioactive waste will be produced each year for each family that is served. Think it over. Do you know what the real costs are?

Nuclear wastes are deadly. They are highly radioactive, and radioactivity is known to cause birth defects, heart disease, cancer, and even death. Today, each nuclear fission plant presents two constant threats to our environment. One is the release of radioactivity through accidents at the plant. The second is the release of radioactivity from the wastes which the plant produces.

We have already had too much of both of these threats. An airplane crashed recently one-half mile from a Colorado nuclear plant. Who is to say that it could not have crashed even closer? Freak accidents are always possible both from inside and outside the power plant. Also, the methods we are using to get rid of the wastes of nuclear fission are not foolproof. We have buried the wastes in double-walled steel and concrete tanks. But leakage from these tanks has occurred and has threatened the ground water supplies of nearby areas.

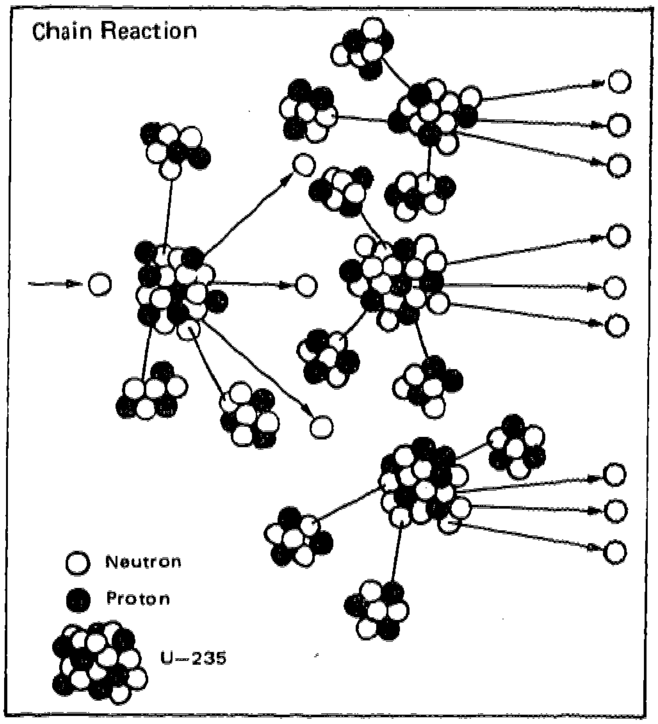
Think again about the costs. How many millions of pounds of radioactive wastes—which remain highly radioactive for hundreds or thousands of years—do we really want ourselves and our descendants to live with on this planet?

What Is Nuclear Power Today?

Nuclear power today provides about 5 percent of our nation's electricity. This amounts, as you saw on the Energy Pie previously, to less than 1 percent of our total energy consumption. It is thought by many that the use of nuclear power will grow. In fact, it is estimated that nuclear power might be increased to supply 23 percent of our nation's electricity demands by 1980. Whether the estimate will come true or not remains to be seen. Today, the future of nuclear power in our country is a matter of great controversy. The picture is always changing, based on consumers' needs, available technology, and concerns both for the economy and for the environment.

Fission

Nuclear power plants produce energy in a reactor by a process of splitting large atoms into smaller atoms. This process is called fission. A small particle of matter—a neutron—hits the nucleus of a uranium atom and combines with it. Then the whole thing breaks into two large fission fragments releasing a large amount of energy. Two or three free neutrons are also released. The free neutrons strike other uranium atoms, causing more fission and releasing more neutrons to split more atoms. This series of events is called a chain reaction. The large fission fragments produced in the chain reaction heat up the reactor core as they collide with other atoms. Thus, the energy released in fission is converted into heat energy.



The heat produced by fission is used to produce electricity in nuclear power plants. The heat is used, as it is in a fossil-fuel power plant, to change water into steam. The steam spins a turbine. The turbine then runs a generator which produces electricity. The main difference between a nuclear power plant and a fossil-fuel power plant is the method used to produce heat. In a fossil-fuel power plant, the heat is produced in a boiler by burning coal, oil, or gas. In a nuclear power plant, heat is produced in a reactor by a controlled chain reaction of uranium atoms. There is another difference between fossil-fuel and nuclear power plants. It is the amount of fuel needed to produce the heat that eventually runs the turbine. One ounce of the uranium fuel that is used in the fission process can produce as much power as 100 tons of coal.

The Boiling-Water Nuclear Reactor

The type of reactor most commonly used in the United States today is the boiling-water nuclear reactor.

1. **Reactor Core:** Small pellets of uranium fuel are sealed in metal tubes. These tubes are combined into bundles and held in place by a grid.

2. **Control Rods:** When fission is occurring too frequently, a few control rods are inserted into the reactor core. The rods slow down the chain reaction as they absorb free neutrons which might otherwise cause fission. When all the rods are fully inserted between the fuel reactions, the chain reaction stops. As the rods are gradually withdrawn, the power level of the reactor increases.

3. **Moderator and Heat Transfer Agent:** The water flowing through the core of the reactor does two things. First, it slows the speed of the free neutrons. The slower moving neutrons have a greater chance of causing fission. Second, the water carries heat energy away from the reactor core as it boils and forms steam. The steam is used to generate electric power.

4. **Reactor Vessel:** Since the reactor produces steam at high temperatures and pressures, a strong housing is needed. The housing also acts as a radiation shield. Harmful radiation from radioactive wastes produced in the reactor is stopped by the reactor walls.

Our Nuclear Past

In 1942, during World War II, our government began research on the military uses of nuclear power. Three years later, the American public heard of the atomic test bomb that exploded in New Mexico with the force of 17,000 tons of TNT. The test bomb was followed a month later by the bombing of Hiroshima and of Nagasaki in Japan. The loss of human life—92,000 in Hiroshima and

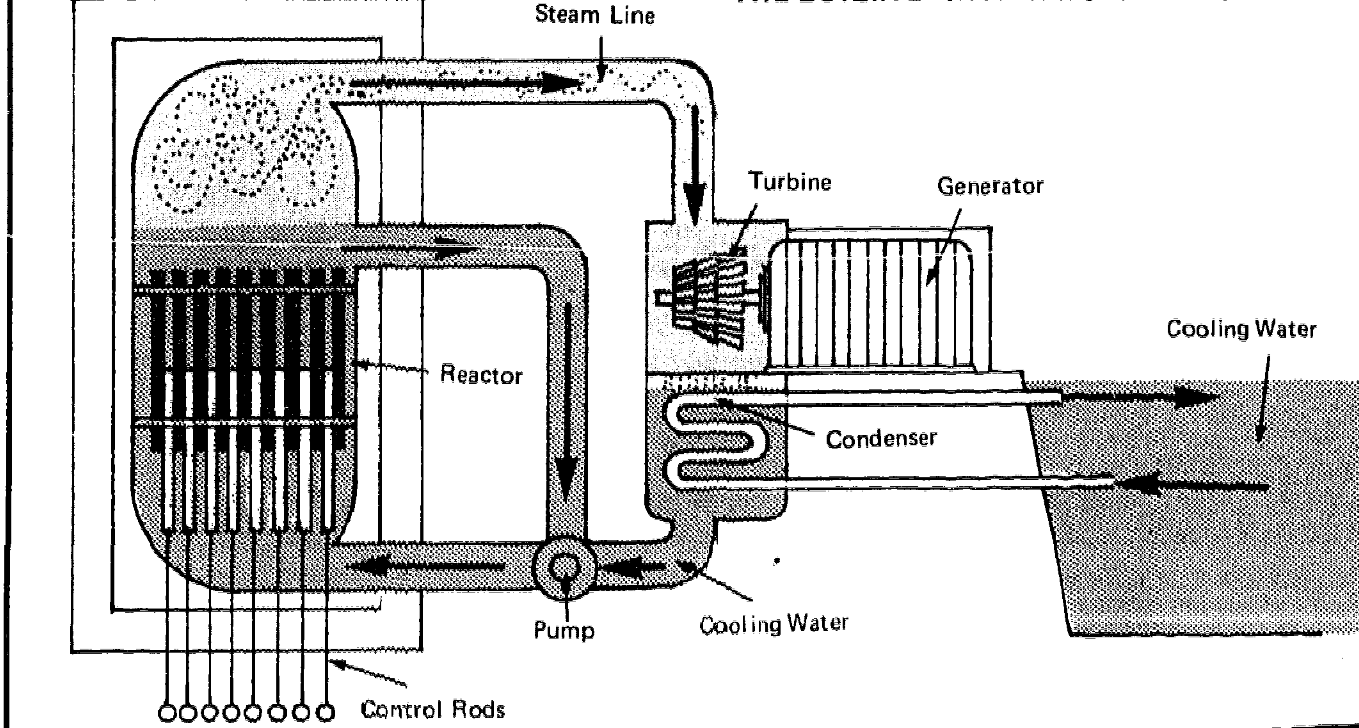
40,000 in Nagasaki—shocked the world. Nuclear explosions had ended World War II. But the destructive power of nuclear energy became a constant threat to all people around the globe.

The Atomic Energy Act

The Atomic Energy Act of 1946 created the Atomic Energy Commission (AEC). This government agency still directs the development, use, and control of nuclear energy for defense and for peaceful applications. In 1954, the Act was changed so that industry could work with the AEC to develop more uses of nuclear energy.

A second change in the Atomic Energy Act came in 1964 when industry was permitted to buy and own nuclear fuel, rather than just lease it from the government.

THE BOILING–WATER NUCLEAR REACTOR



The Promise Of Nuclear Electric Power

The biggest peacetime use of nuclear energy has been for electricity. The electric utility companies were quick to act in 1954 when the government opened up nuclear technology to industry. Together, the Atomic Energy Commission and the utilities made nuclear electric power into a multi-billion-dollar industry.

Nuclear power plants seemed to have many advantages over fossil-fueled plants. For the consumer, the price of nuclear electric power was as low as power produced by other means. And the nuclear power industry promised even lower rates in the future.

Nuclear power stations were quiet and attractive. They also appeared to be clean, producing no visible air pollution.

The producer found the cost of uranium fuel lower than other fuels. (For ten years, the government absorbed some of the cost of producing uranium fuel.) Shipping and storing nuclear fuel was also easier and cheaper since only small quantities of fuel were needed. For example, a million-kilowatt nuclear plant needed only 35 tons of uranium fuel per year. A coal-fired plant of equal power used 2 million tons of fuel per year! A nuclear plant was refueled only once a year. A fossil-fuel plant needed continuous refueling.

Nuclear power appeared to be a clean, cheap, efficient way of meeting the public's demands for more and more electric power. It was also a way of saving valuable fossil fuels for other purposes.

In 1956, England was the first country to provide homes and businesses with electricity from a nuclear power plant. America soon followed and soon outran England in sheer output of nuclear energy. Here, the first big nuclear station began operation in 1957, in Shippingport, Pennsylvania. This plant still provides electricity to the Pittsburgh area. Both power plant "firsts" were constructed near plentiful supplies of water. Later, you will find out why.

By late 1967, eleven nuclear power plants with generating systems larger than 10,000 kilowatts were operating in the United States.

In late 1973, there were thirty-seven nuclear power plants operating in the United States. However, due to safety problems, twelve were shut down for repairs and only five were operating at full capacity. An additional fifty-seven nuclear plants were in the construction stages in late 1973. If these are completed—and the eighty-nine more that have been planned—then, according to the Atomic Energy Commission, the nation's electricity future will be much brighter.

Nuclear Or Not—Where Do You Stand?

By the year 2000, the nuclear industry hopes to supply over half our nation's electric power. The government supports further development of fission power. But environmentalists and concerned citizens oppose present plans for nuclear expansion. They are worried about matters of health and safety. They feel that many questions must be answered and many problems solved before we invest our future in nuclear fission. The problem areas are described in the following sections. After reading them, reread the earlier statements for and against nuclear power. Then decide for yourself where you stand on the issue of "nuclear or not."

Thermal Pollution

Nuclear power stations need large amounts of water for cooling. When this hot waste water is put into nearby waterways, it changes the environment in and around the waterway. Changing and destroying the natural balance of life in a waterway is called thermal pollution. The first nuclear stations caused a great deal of thermal pollution. Later, cooling towers were constructed to cool the waste water before returning it to waterways. However, this method is quite expensive.

Radiation And Human Life

The fission products or wastes produced in the reactor of a nuclear power plant are highly radioactive. This means they emit large doses of radiation (energy in the form of particles and waves). This radiation cannot be detected by the senses, but is extremely harmful to human life.

The cell is the basic unit of life. When radiation is absorbed, it can produce abnormal changes in human cells and can even kill them. Our bodies continually grow new cells to replace dead ones. But large doses of radiation can cause permanent damage by killing more cells than our bodies can immediately replace. The abnormal changes in cells produced by radiation may one day lead to cancer or leukemia (blood cancer).

The unit used to measure the biological effect of radiation on man is the millirem. In many areas of the United States, natural radiation from the sun is 125 millirems. Medical and dental X rays could add another 50 millirems. The AEC and the nuclear power utilities claim that modern technology has reduced the radiation danger from nuclear plants to less than 1 millirem per year. They often describe you, the consumer, spending the rest of your life living near a nuclear plant and getting less total radiation from the plant than from one chest X ray.

However, many scientists estimate that natural radiation probably causes from 5 to 10 percent of human health problems, such as birth defects and premature death. Many citizens don't want to add even more radiation to the environment from possible accidents at a nuclear plant or from poor disposal of the radioactive nuclear wastes that a nuclear plant produces.

Radiation increases the risk of future cancer or leukemia fifty times more when it affects an unborn child than an adult. The period between radiation exposure and leukemia takes four or five years. Other cancers may occur as long as twenty years after exposure. Has this length of time made us less aware of the real threat that radiation is to human life?

Radioactive Wastes

Great care is taken to see that radioactive wastes in a nuclear power plant do not escape into the environment. But small amounts do appear in the gaseous and liquid wastes leaving the plant.

Once the fuel in a reactor is spent or used up, the fuel rods are removed and shipped in shielded containers to a reprocessing plant. There, valuable uranium and plutonium are removed. Then the radioactive fission products are stored in solution in double-walled tanks. After five years, the solution is evaporated and the solid fission products are sealed in steel containers. Finally these containers must be safely stored for a thousand years or more until the radioactivity goes down to a safe level. A plan to bury these wastes in salt mines is now being tested. Another plan is to shoot the wastes into the sun on rockets. No disposal plan yet invented is foolproof against possible accident. Leakage from the tanks of liquid radioactive wastes has already occurred in a number of places.

Danger Of Accidents

A serious accident or explosion at a nuclear power plant would be a catastrophic event. The quantity of radioactive wastes in a reactor is many times greater than the radioactive fallout released by the bombs dropped at Nagasaki and Hiroshima. Since most nuclear power plants are located in populated areas, a serious accident could result in thousands of deaths due to radiation exposure.

The chance of a serious accident is very slim indeed. But the chance remains. Many people feel that the safety systems need additional testing and that construction of new plants needs stricter supervision to insure the public against possible disasters.

The Problems Of Uranium

Uranium, the material which fuels a nuclear reactor, might seem to be an ideal fuel. Small amounts produce huge amounts of power. And, since only small amounts of uranium are needed, storage and transportation are fairly easy.

But the use of uranium fuel does present some problems:

1. Only 1 percent of the uranium found in nature is useful as a fuel in our present nuclear fission reactors. This small part, called uranium 235, undergoes fission when struck by neutrons. The remaining 99 percent of natural uranium, called uranium 238, is not fissionable.

2. Huge amounts of electric power are needed to produce uranium fuel from natural uranium. The fuel contains a larger percentage of the fissionable material, uranium 235. It is produced from natural uranium by a process known as uranium enrichment. In 1973, 3 percent of our total electric power use went to uranium enrichment.

3. We are rapidly using up our reserves of uranium. In less than 30 years, low-cost uranium will be in very short supply.

Fast-Breeder Reactors: The Future Of Fission

A new type of reactor is now being developed which could make our uranium reserves last for thousands of years. The reactor, called the fast breeder, produces its own fuel by changing uranium 238 into plutonium. Plutonium is a fissionable material which can fuel the fast breeder once it is produced. In this way, 100 percent of natural uranium would be used as a fuel instead of only 1 percent.

The breeder reactor is still experimental, but it might be available between 1985 and 1990. However, critics of the fast breeder are worried about accidents. They point out that the first one that was built had to be shut down. It "self-destructed" due to intense heat. The breeder operates at a higher temperature than the present-day reactors operate. Therefore, the threat of explosion is greater. The production of plutonium in large quantities presents another danger. Plutonium is perhaps the most dangerous of all radioactive materials. And it remains highly radioactive for thousands of years.

TAPPING NEW SOURCES

FUSION

The Promise Of Fusion

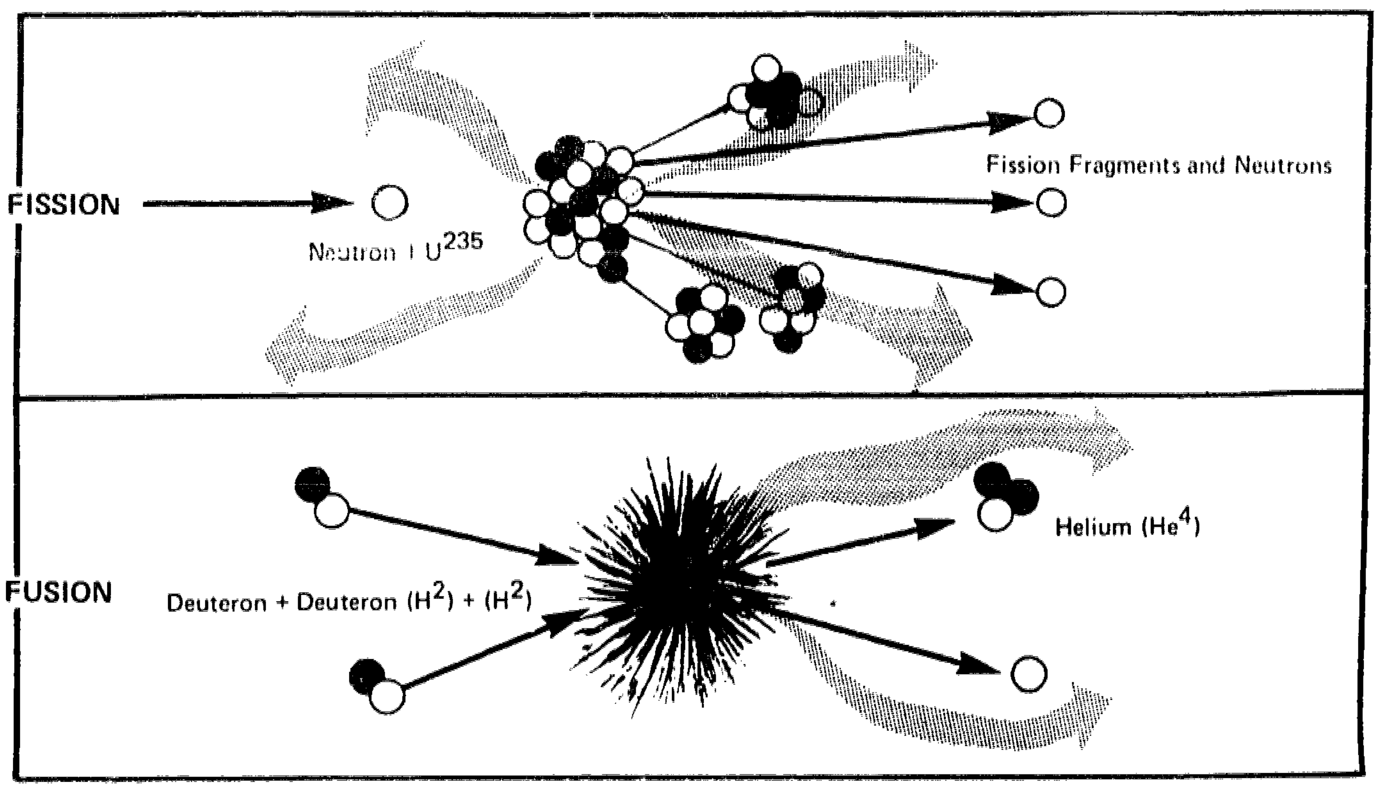
Many scientists feel that we can duplicate and use the sun's way of generating heat energy. The sun is a giant nuclear furnace It has been blazing for over 4,000 million years. The energy which reaches our planet as heat and light comes from fusion explosions inside the sun. Simply stated, fusion is the joining of two light nuclei, such as the nuclei of hydrogen. The two are joined into one heavier nucleus, such as helium, with some particles and a great deal of heat energy left over. For ages and ages, fusion energy from the sun has made life possible here on Earth.

Experiments to control and use nuclear fusion have been going on for more than twenty years. Fusion explosions are the basis of the H-bomb, or hydrogen bomb. However, controlled fusion is still experimental today. We have not yet built a fusion-based nuclear power reactor. In 1974, $80 million of government money was set aside for fusion research and development. However, this amount is small compared to the $400 million that was set aside to further develop nuclear fission.

There are real advantages to nuclear fusion as an energy source The advantages include.

1. **A guaranteed supply of cheap fuel** The primary fuel for fusion is a form of hydrogen known as deuterium or heavy hydrogen. We can easily obtain enough heavy hydrogen from the ocean waters on our planet to last us hundreds of millions of years. And the cost to isolate this plentiful fuel from water may be smaller than the cost to obtain fossil fuels or uranium.

2. **Much less danger than nuclear fission** In case of an accident in the reactor, fusion reactions stop immediately. There is no danger of nuclear explosions as there is in a fission reactor. Radioactive materials are produced in fusion reactors. But the amount of radioactive waste from fusion is very small compared to the wastes from fission.



The [illegible]hnical Problems

To make fusion power work for us, we must carry out the following steps.

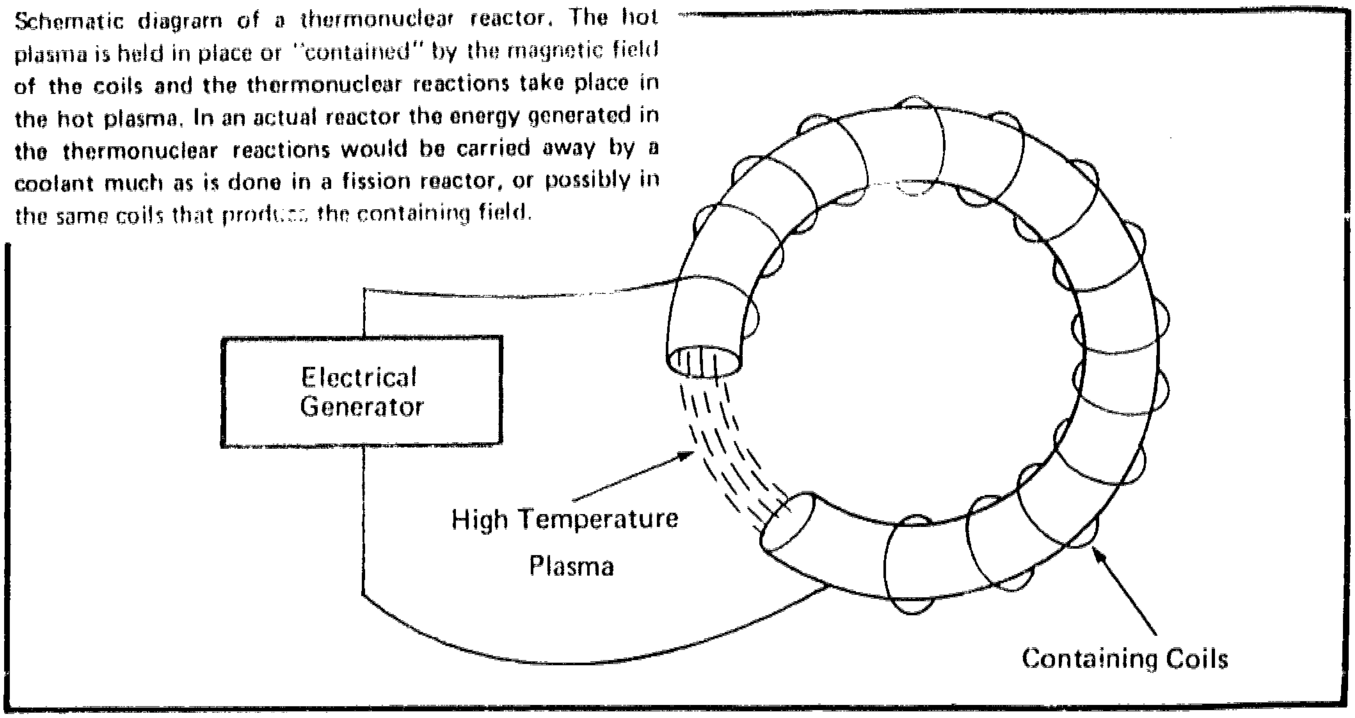
1. **Heat a small quantity of fusion fuel to about 100 million degrees C.** At low temperatures, nuclei do not fuse. Electrical forces between the positively charged nuclei tend to keep the nuclei apart. But at very high temperatures, the nuclei have enough energy to overcome the electrical forces and to crash together and fuse.

2. **Keep the fuel hot long enough for many fusion reactions to take place.** Then the energy released in the fusion reactions will be much greater than the energy needed to heat the fuel. The hot fuel must also be kept away from the walls of the reactor since the walls would melt and vaporize at such high temperatures.

3. **Convert the energy released by fusion into electricity.**

Scientists are presently working on steps 1 and 2. They have found several ways of heating the fuel and confining it long enough for fusion to take place.

Schematic diagram of a thermonuclear reactor. The hot plasma is held in place or "contained" by the magnetic field of the coils and the thermonuclear reactions take place in the hot plasma. In an actual reactor the energy generated in the thermonuclear reactions would be carried away by a coolant much as is done in a fission reactor, or possibly in the same coils that produce the containing field.



The Magnetic Bottles At very high temperatures, the hot gas fuel becomes a plasma, a gas of electrically charged particles. The plasma is made up of the nuclei and the electrons of the original fuel matter. Scientists use a doughnut-shaped "magnetic bottle" to keep the hot plasma away from the walls of the reactor. The "magnetic bottle" is really a strong magnetic field which makes charged nuclei follow a curved path along the magnetic lines of force. So far the energy needed to create the magnetic field and heat the plasma is greater than the energy released by fusion in the "magnetic bottle."

Laser Fusion In another scheme, a pellet of fusion fuel is dropped into a vacuum chamber. It is bombarded with laser beams which heat and compress the fuel, creating a very small nuclear fusion explosion. Hundreds of these explosions are needed to make fusion power useful.

Difficult technical problems remain to be solved before fusion can ever produce electricity. However, scientists do feel that if enough money is spent for research, fusion reactors would be available for commercial power production by the year 2000.

Energy From The Earth

When people watch Old Faithful send a fountain of boiling water high into the air, or see a flaming volcano pour forth molten lava, they realize something. The inside of the Earth is hot—about 4000°C at the center. The heat energy inside the Earth is called geothermal energy. Many scientists believe the heat is produced by the decay of radioactive materials in the Earth's interior. In most places, the heat spreads out as it flows to the Earth's surface and is barely noticeable. But in some places, such as volcanic regions, the heat is concentrated. Temperatures of 300°C to 600°C may exist only 1,000 meters below the Earth's surface.

Naturally, people have asked, "Why not make use of the heat energy inside the Earth?" Some people already have. In Reykjavik, Iceland, people have been heating their homes for twenty-five years with natural hot water piped from an underground source. A geothermal steamfield plant in Larderello, Italy, has been providing electricity to run Italy's railroads since 1904. In Kenya in Africa, geothermal energy hatches chickens.

So far, our nation's only geothermal power plant is in the geyser area north of San Francisco, California. Here, hot rocks beneath the Earth's surface turn water from an underground lake into steam. The steam rises through natural openings in the Earth. The steam is pumped to a power plant and used to generate electricity for the city of San Francisco eighty-five miles away.

The source of the heat in all cases is molten rock. However, the way the heat gets to the surface to be used depends on the geological conditions of the area. There are three types of geothermal sources:

1. **"Dry" steam from underground reservoirs that springs up from its own pressure** Geysers of natural steam, however, are very rare.

2. **Hot water and steam from underground that must be tapped by wells** This is the source presently used by most geothermal power plants. Once a well is drilled, the steam is forced to the surface by natural pressures. Electric power from geothermal plants is competitive in price with power from fossil-fuel plants. Unfortunately, there are not many natural underground reservoirs of steam and hot water.

3. **Dry hot rock which is used to heat water** The water is pumped down from the surface through a hole drilled by an oil rig. The water pressure cracks the rock; the water is heated and percolates up a second hole. Of all three sources, this one offers the greatest possibility. There are at least a thousand hot rock beds in the Western states and some in Pennsylvania and upstate New York. But so far, this method has not been tried.

In 1974, the United States set aside almost $45 million for geothermal research and development. By March, 1974, a large number of applications—2,456 to be exact—had reached the federal Department of the Interior. Each of these applications contains somebody's plan to explore federal lands for geothermal energy. Do you think geothermal energy might be a big energy source in the future?

Tapping geothermal energy presents some problems:

1. The hot water and steam often contain salts and other minerals that clog and corrode the well shafts and the machinery of the power plants. Since many of these minerals are harmful, they must not be allowed to enter the atmosphere or nearby waterways.

2. No one knows how ground water supplies are affected by withdrawing hot water from underground reservoirs.

3. Injecting water into hot rock beds may cause shifts in the Earth's crust.

Spaceage Windmills

Can we put winds to use to help produce electricity? Can we store the energy produced during periods of strong winds for times when the wind dies down but the energy is still needed?

The answer to both questions is yes. The power of the wind is enormous. It is a clean source of energy. It is constantly renewed as the sun's energy warms up the atmosphere. However, we must consider how much wind power we would want to use. Suppose we suddenly wanted all the electricity for the United States to be produced by windmills. It would require windmills 300 feet high and a mile or two apart across the whole country. Would this be practical?

In the small nation of Denmark, windmills are a practical way of producing electricity. Coal and oil are scarce there and water power is in limited supply. Also, Denmark's strongest winds occur in the winter, when electrical heating demands are greatest. Even back in 1915, Denmark had 3,000 windmills in operation.

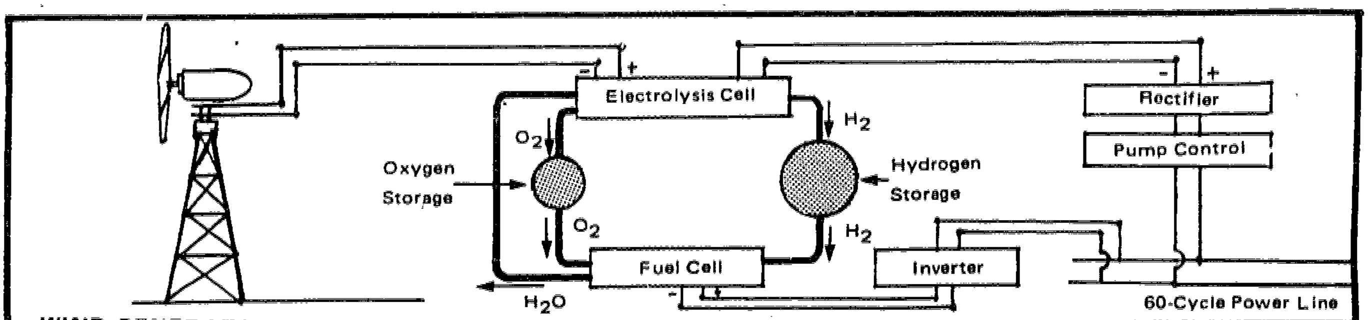
Wind can produce electricity rather easily. The wind pressure against the windmill's vanes or propellers produces a rotary motion. The propellers spin a shaft which turns the coils of a generator, thus producing electricity. When wind speeds increase, wind pressure increases too and more electric power can be produced. The problem arises when the wind dies down. Then the generators stop. If power is needed on a small scale, electrical energy can be stored in batteries and the batteries can supply power on windless days. In the United States, thousands of windmill generators are used to light farms and charge batteries in areas where electric utilities do not supply electric power.

The use of wind generators as a major source of electric power is not likely in this country. Huge windmill generators are expensive to build. Also, a convenient method would have to be found to store energy on a large scale. Electric power from wind generators could be used to produce hydrogen gas from water. The hydrogen gas could be stored and used for fuel when needed. However, the use of hydrogen would require changes in present technology. (See the articles on fuel cells and the hydrogen economy.)

But in certain areas of the United States where winds are strong and steady, wind power seems to be the best source of energy. Would the area around your home or school be a good site for a windmill generator? High mountain regions are good because of their openness to strong, steady, and prevailing winds. The shape of the mountain, however, can sometimes slow down the flow of the wind.

In 1973, the United States government launched a five-year program to develop new windmills for use in certain rural localities. For example, an experimental windmill might soon produce electric power for a few families in rural Ohio. This windmill has blades of steel or Dacron. It can provide power at an even rate as long as the wind is above 18 miles per hour. As the speed of the wind changes, self-adjusting hinges change the position of the blades to keep the blades rotating at a constant speed.

Other nations of the world are seriously investigating the windmill's possibilities too. They are Russia, Britain, France, Spain, Israel, Egypt, India, some African nations, and Argentina.



WIND GENERATOR

Garbage Power

A man named Harold Bates, who lives in Devonshire, England, runs his 1953 automobile on chicken and pig droppings. Many of the people of India use pails and shovels to collect cow dung from the streets. They use it to heat their homes and to cook their meals. Some of the cities in Europe and the United States are turning their garbage into heat and electricity.

Can waste materials help to ease us out of the energy pinch? To answer this question we must know these things:

1. Which waste materials can we convert into useful energy?

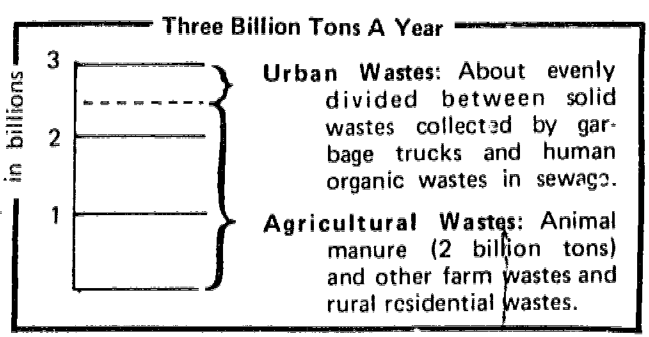
2. What technology do we need to convert garbage into "garbage power?"

3. How much energy can we get by converting the usable wastes?

4. How much will we have to pay for garbage-power?

Which Materials Can We Use?

Every year, the United States produces three billion tons of garbage. This amount does not include either sewage wastes or the wastes from industry. Garbage removal alone costs us $3 billion a year. There are other costs, too, such as removing solid wastes from sewage so we can clean up the water. We spend waste disposal money on incinerators, landfills, and even on filthy open dumps. Sadly, what we often get for our money is pollution, caused by the burning, burying, or dumping of our wastes.



Can we put our waste disposal money to better use and help to fight pollution as well? One speaker for garbage-power has said that the wastes from a family of five, plus an animal or two, plus all the household garbage, could be converted into 85,000 Btu's every day—enough to supply the whole family's needs for household fuel!

Wastes might appear to be a cheap source of power, a source which is continually renewed. The daily garbage of our cities and towns, and the organic wastes from animal feedlots, food processing plants, and municipal sewage are available in great quantities. We have the technology to convert these wastes into useful power. However, collecting, transporting, and sorting solid wastes is expensive. Presently these high costs limit the use of garbage for power production.

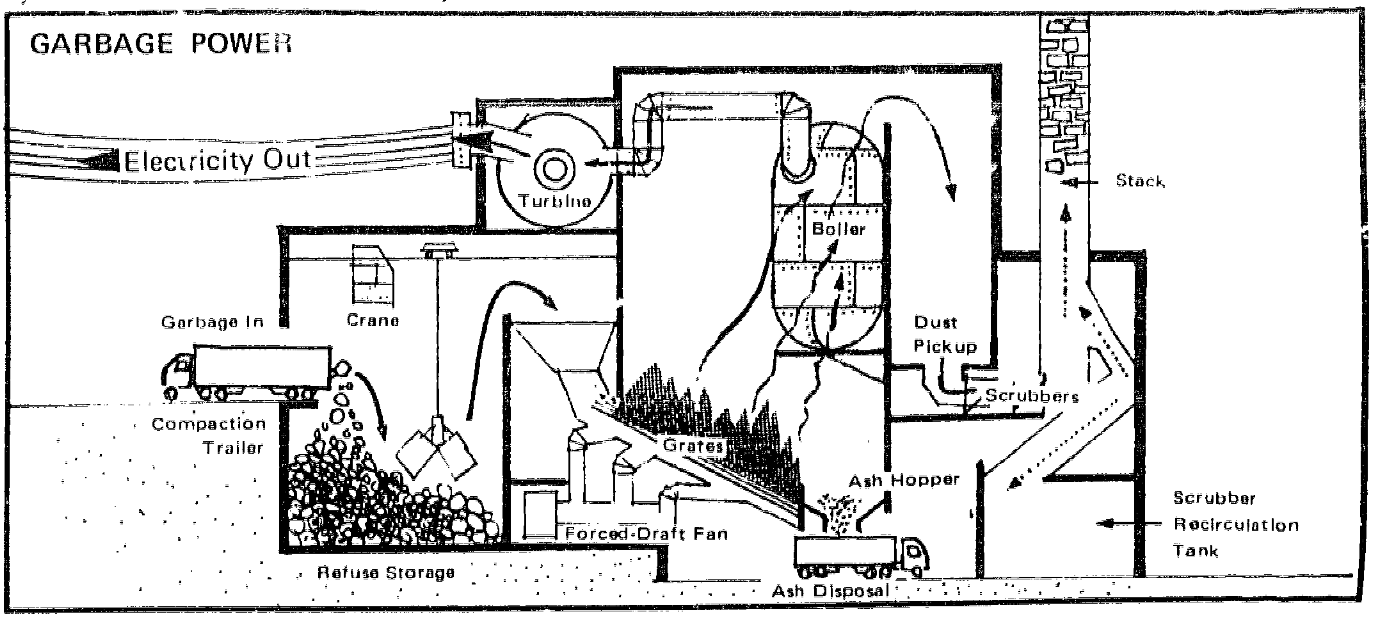
Conversion Technology

Anaerobic Digestion Methane gas is the chief ingredient in natural gas. Did you know that methane gas is percolating beneath many of our sanitary landfills? This gas is produced as bacteria decompose organic wastes buried in the soil. The process is called anaerobic digestion (digestion in the absence of oxygen). Some people have suggested that we tap and use methane for fuel by drilling wells into a landfill and then pumping out the gas.

In a landfill, anaerobic digestion is an act of nature. We know how to imitate that act. We can use anaerobic digestion to turn our sewage wastes and the animal manure from our big farms into methane gas. To do so requires a series of big storage tanks and a network of pipes. After the organic wastes have decomposed, the methane gas can be pumped out and used.

Methanol Methane gas is a substitute for natural gas. Also, it can be converted into a substitute for gasoline, called methanol. Actual road tests have proved that a mixture of methanol and gasoline can give better mileage, cause less air pollution, and be less expensive to use than gasoline alone. Can you understand now how Harold Bates fuels his automobile?

From incineration to electric power For many years European cities have used the heat from burning garbage to run boiler furnaces. Steam power from the boilers is then converted to electric power. In North America, only a few small incinerator-to-electric systems are now operating. But by mid-1977, the St. Louis area plans to become the first region in the United States to use all of its solid wastes to generate electricity. Under the plan, glass and metals will be separated from the garbage. The remaining waste will be shredded, mixed with coal, and then used as a fuel for electric-power generation.



Incineration, either for garbage disposal or for energy use, is controlled in the United States by the Clean Air Act of 1970. Since it is possible to incinerate waste without polluting the air, we may someday see much of our garbage recycled into electric power. Conversion of municipal garbage into electric power could provide up to 3 percent of our total energy demand.

Pyrolysis In this process, organic wastes of all kinds including plastics are "cooked" or "roasted" at very high temperatures in the absence of oxygen. Without oxygen the wastes decompose but do not burn. Oils, gases, char, and water are produced. The oils and gases can be used for fuel. The char is a possible coal substitute. It can also be used to make filters or fertilizer.

Recover, Recycle, Reuse

Our garbage can really work for us, and in ways that help us preserve the environment. Let's consider the example of a typical city's daily garbage. It is a huge amount, in tens or hundreds of tons. Almost half of it is paper. The citizens of the city could help by separating their paper wastes from the rest of the garbage before everything is collected.

The garbage can then be put to good use. Some wastes can be recycled and reused. Others can be turned into the fuel substitutes we want—substitutes for natural gas, gasoline, coal, or fuel oil. Here are the steps we can take:

1. Remove large metal objects (such as washing machines) and some paper wastes from the garbage. Recycle the metals and the paper.

2. Shred the rest to reduce the volume of the garbage.

3. Remove organic wastes and process them by anaerobic digestion into fuel and fertilizer.

4. Remove small metal pieces by magnets. Recycle the metals.

5. Remove glass. Recycle the glass or use it in construction and road building.

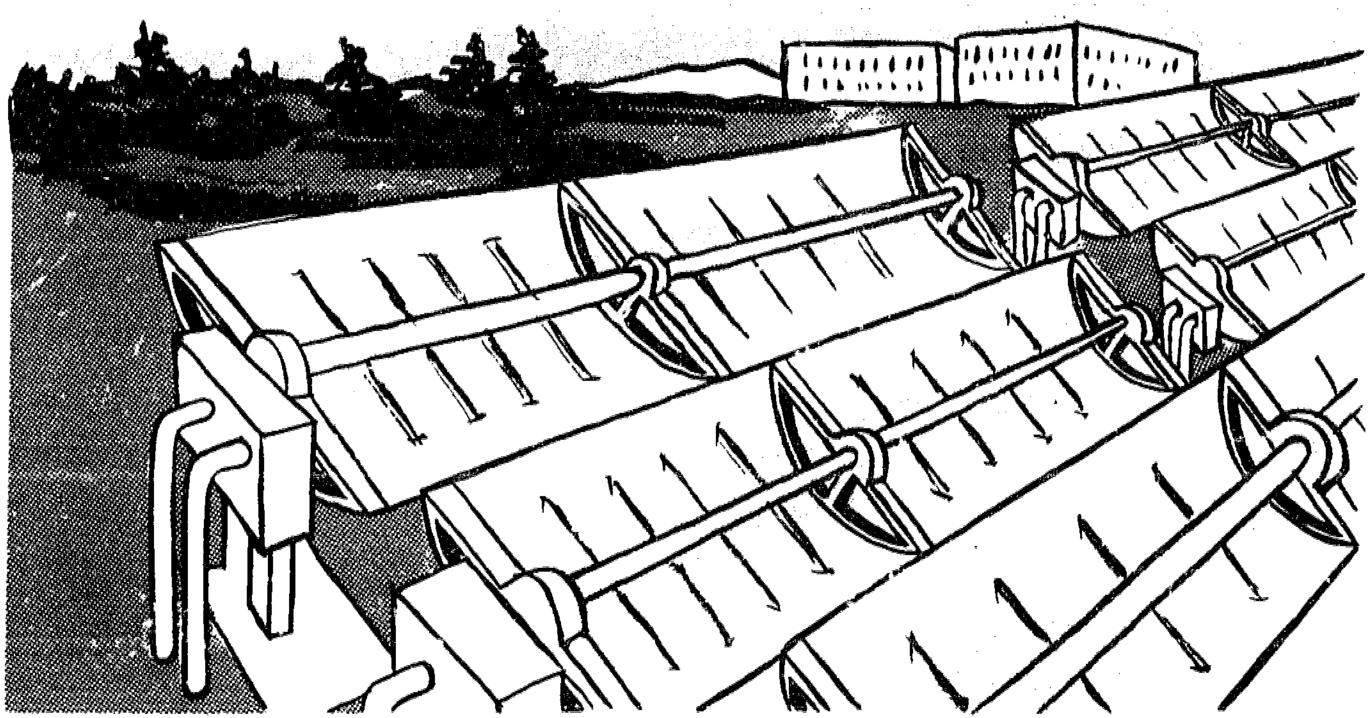
6. Recycle the rest (about 20 percent of the original volume of the garbage) into the desired fuel-substitute by pyrolysis. The products of pyrolysis can be varied at will by changing conditions such as the timing and the temperature.

SOLAR

Directly From The Sun To You

You know that the sun is the source of all energy on Earth. Energy from the sun provides us with the foods we eat. Stored solar energy has provided us with the fossil fuels we use. Now, plans to use the sun's energy as a direct source of fuel are being developed. Three of the new plans for solar-energy use are:

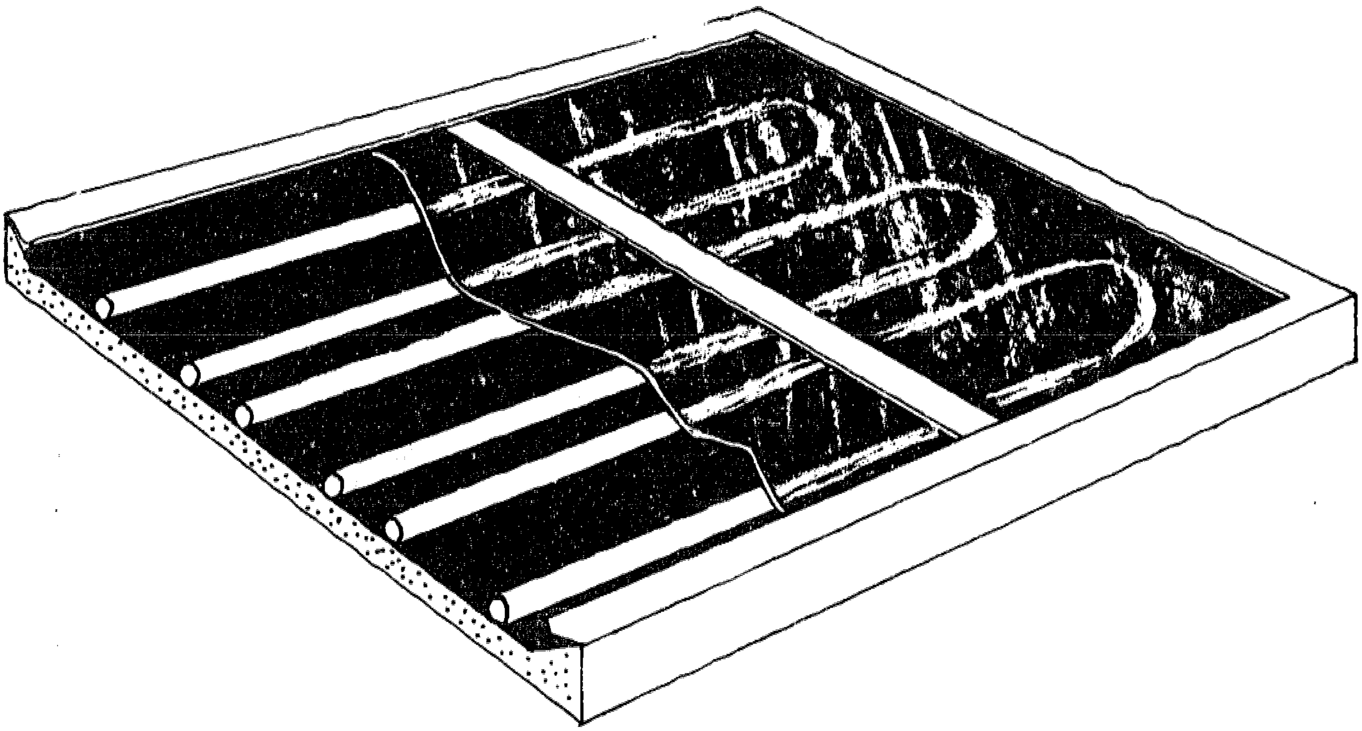
1. **Central power stations or "solar farms"** The sun's heat can be collected on deserts, perhaps, or even in the seas and then converted into electricity. The electricity can then be sold to homes and industries.



2. **On-site collection of the sun's heat and conversion of heat to electricity** Tested conversion systems already provide space heating and hot water (and someday perhaps air conditioning and cooking too) on a direct sun-to-house basis. Once installed, a solar energy system can supply almost free fuel. Also, the user can worry less about blackouts, power failures, or the rising cost of fossil-powered electricity.

3. **Conversion of solar energy to electricity in space** Satellite power stations could beam electricity down to the Earth at microwave frequencies. By orbiting the satellites above the Earth's weather conditions, a constant energy source would be guaranteed. However, there is some

A TYPICAL SOLAR–ENERGY COLLECTING PANEL



danger that this plan, which is still a theory, might be harmful. We need to know how our environment might be affected in the long run by satellite-beamed microwaves from space.

Solar Energy: The Current Scene

The federal government allocated $12 million for solar energy research and development in 1974. This was the largest amount of federal money ever put to solar energy use, although it may seem small in contrast, for example, to the $400 million set aside for nuclear fission research in 1974.

New solar energy projects are rising up all over the country today. By 1974, twenty-five solar powered houses were in operation. These were either privately built or built by universities. As early as 1938, workers with the Massachusetts Institute of Technology had built the first solar house. They knew that the sun radiates an average of 1000 watts of energy daily on each square meter of earth, and they made use of that energy. Do you know how it can be done?

1. First, a black metal plate is heated by the sun. When the plate is hot, it is covered with glass. The glass cover does two things. It traps in the heat (specifically, the infra-red rays) and it allows the sunshine to heat the plate even more.

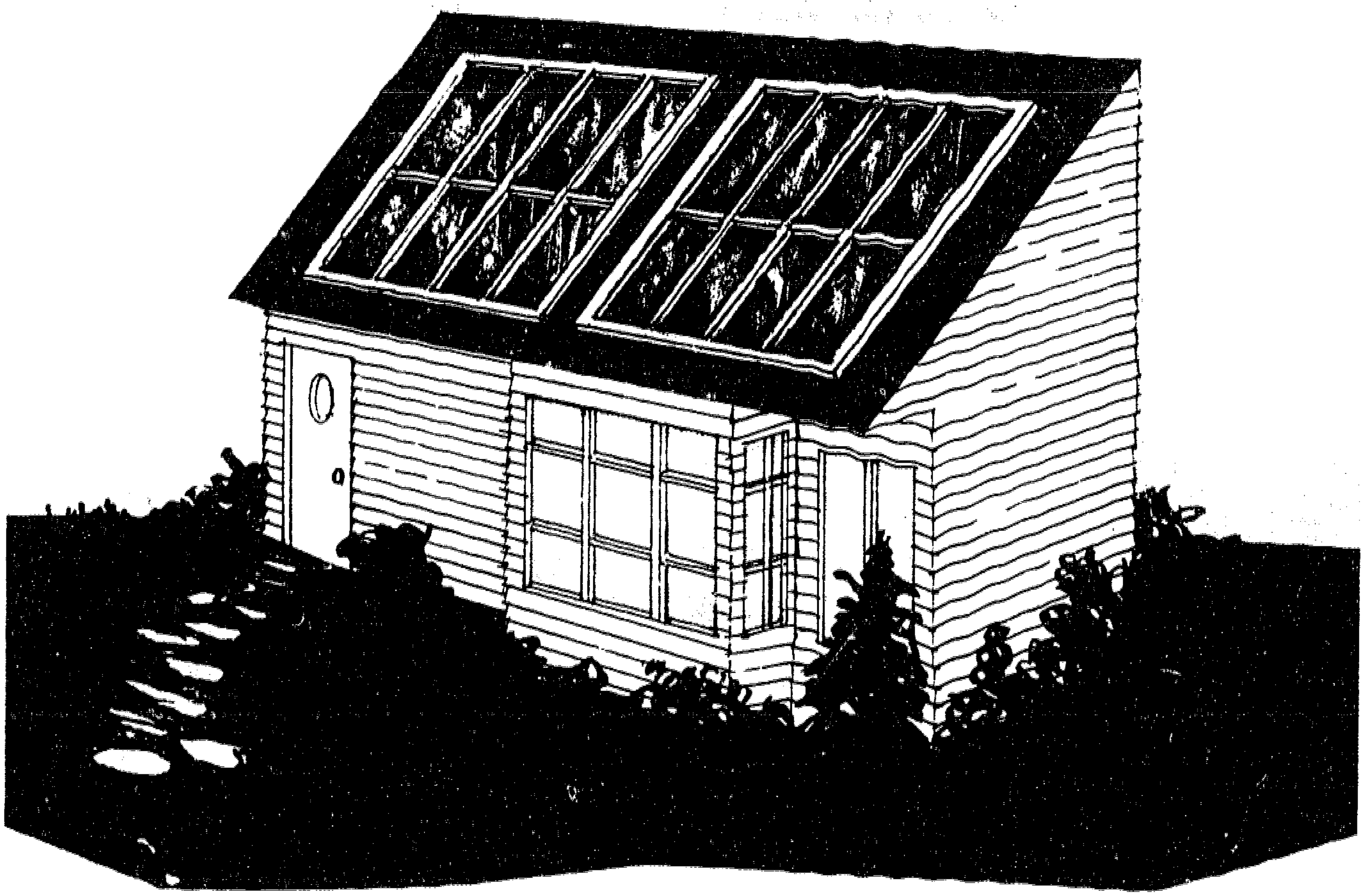
2. Second, the trapped energy must go into useful channels. Usually a fluid—either air or water—is pumped in to carry the heat away to where it can be used.

3. Then, the heat which has been carried off and stored can be used to boil the water which produces the steam that runs a generator!

They Aren't Science Fiction!
A Look At Two Solar Energy Projects

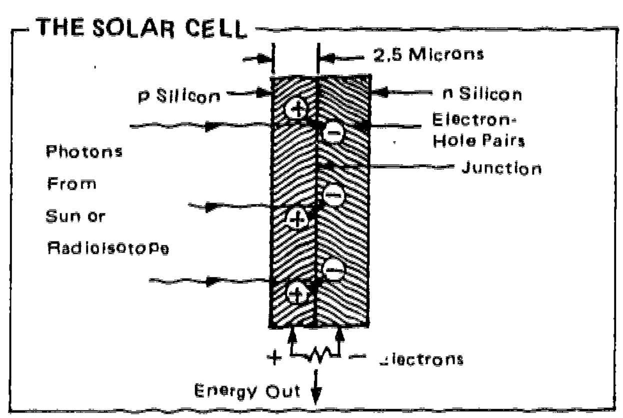
The Delaware Project

In a house at the University of Delaware, roof panels—similar to the typical solar collectors which are illustrated—collect heat. But something new has been added to this solar experiment, which scientists are calling the most technically advanced solar project ever seen. The panels contain cadmium sulfide solar cells that turn part of the solar energy directly into electricity. Behind the panels, air is kept circulating. It keeps the cells from overheating and carries off the excess heat to the basement for storage, and then is used as described above.

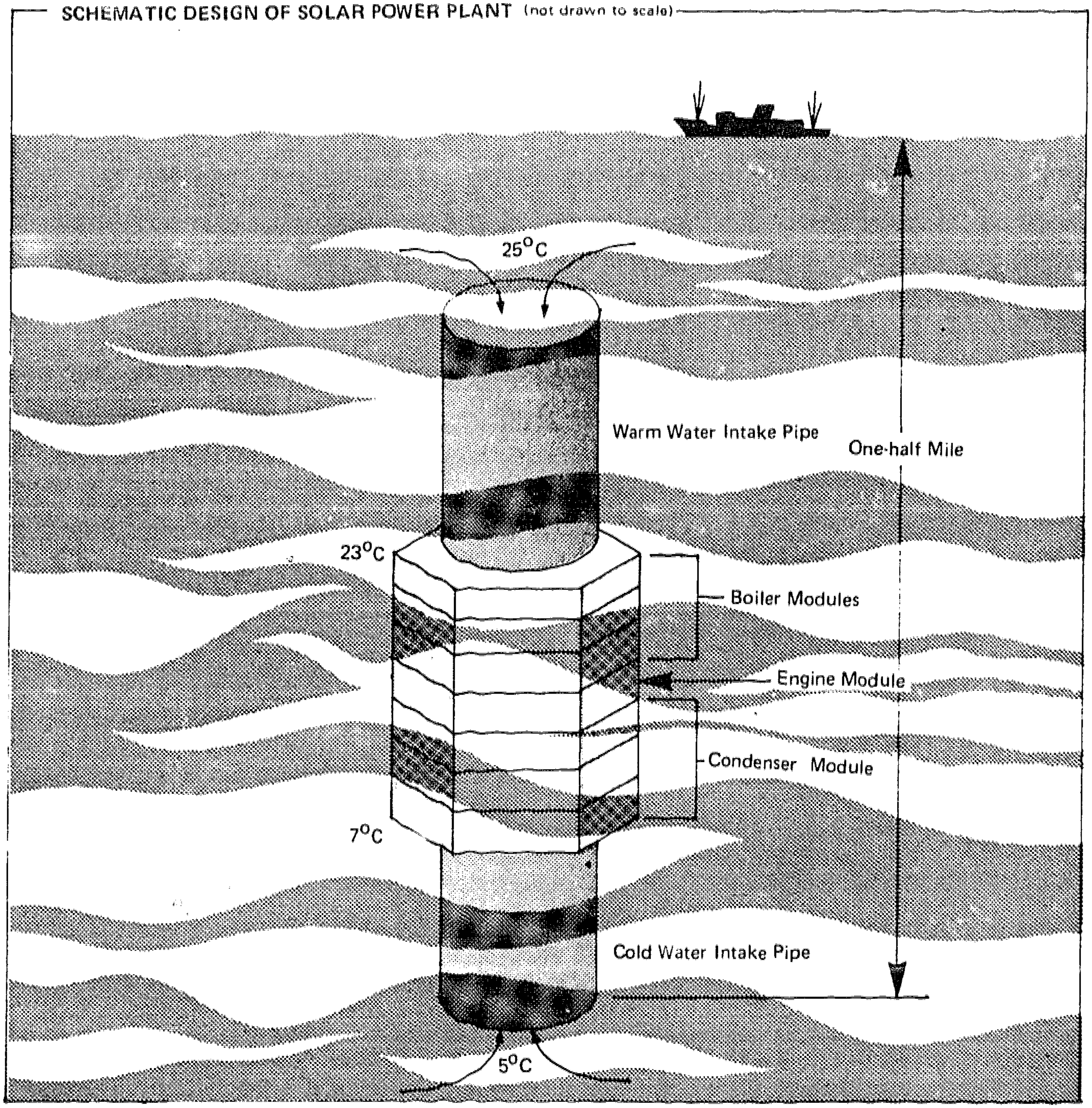


Photons Are Energy-Carriers

A solar cell uses certain semiconductor materials, such as silicone, which will absorb light and generate electricity directly, without an intermediate heat stage. The diagram shows you what a solar cell is composed of. In addition to their use on the house at the University of Delaware, solar cells are put to use in space technology.



SCHEMATIC DESIGN OF SOLAR POWER PLANT (not drawn to scale)



The Floating Power Station Plan

Although it is still in the planning stages, ideas are being shared and costs are being considered now for putting power plants—run by solar energy—into the ocean. Someday you may be using "solar sea power" to heat and light your home! Here is a simplified version of the plan:

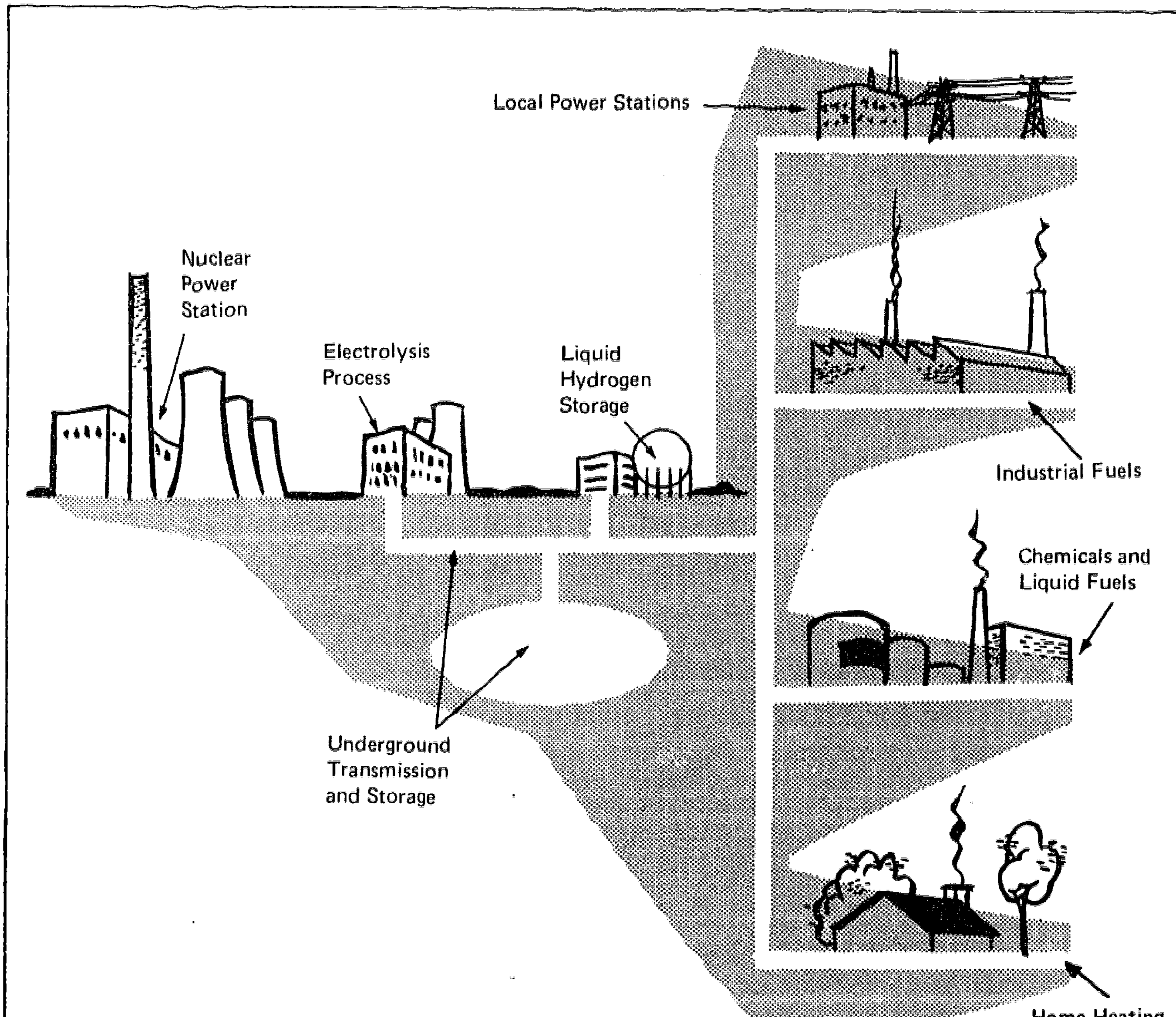
The floating power station could be anchored in a warm ocean current off a coastline. Hanging beneath the power station would be a pipe approximately 35 feet in diameter and reaching a depth of a half-mile. Surface water which has been warmed by the sun is piped into an evaporator. A vacuum produced in the evaporator makes the water boil. The steam is directed to a generator and then condenses the steam back to water. The water is returned to the evaporator, and the cycle repeats itself.

DEVELOPING OTHER WAYS
HYDROGEN ECONOMY

Most of the schemes to tap new energy sources include converting the energy into electric power. Wind energy, solar energy, nuclear energy, and geothermal energy could all be used to generate electricity at large central power stations. For environmental or other reasons, these power stations would probably be built far from population centers. Underground transmission lines would carry power to distant consumers.

But is this the most efficient way of distributing and using energy? Should we be moving toward an "all-electric" economy?

Some people think that a synthetic fuel would be cheaper to deliver and easier to use than electricity. The best candidate for this synthetic fuel is hydrogen. At the central power station, electric power could be used to break down water into hydrogen and oxygen. This process is called electrolysis. The hydrogen could then be transported to the point of use by pipeline (the way natural gas is transported now). There it could be burned as a fuel or used to operate a fuel cell for electric power.



A PROJECTED PLAN

This scheme, known as the hydrogen economy, solves several problems at once. First, it solves the storage problem. Electric power must be used at the rate it is produced. It cannot be stored. But hydrogen can be stored underground or liquefied and stored in tanks for times when power demands are greatest. During times of less demand, the excess power produced at the power station can be used to increase the supply of stored hydrogen.

The hydrogen economy also provides a cheaper, more efficient way of transporting power from the central power station. Gas pipelines are the cheapest way to transmit energy.

Finally, a large supply of cheap hydrogen is very desirable. Pure hydrogen is a clean, nonpolluting fuel. Its only combustion product is water! Home furnaces and industrial equipment can be converted to run on this clean-burning fuel rather than on fossil fuels. Cars can also run on hydrogen. An engine fueled on hydrogen can deliver as much power as a gasoline-fueled engine. And it will burn more cleanly, producing water and only small amounts of nitrogen oxides.

Hydrogen may also be used to generate electricity at local power stations. With pure hydrogen readily available, fuel-cell generators become much more attractive. As described below, fuel cells are very efficient and can be built to supply electric power to individual homes, to commercial buildings, or to a large city.

Critics of the hydrogen economy say that hydrogen is too dangerous to use in the ways described above. Hydrogen gas is highly explosive, and only a small spark of static electricity provides enough energy to start a hydrogen fire. But industry has found ways to handle hydrogen quite safely. If safety measures can be found and fossil-fuel prices continue to rise, we may very well switch to hydrogen as our basic fuel. Then the world would be a far cleaner place to live in than it is today.

THE FUEL CELL

You have already learned how the chemical energy in fuels is converted to electrical energy at a power plant. First the fuels are burned to produce heat. Then the heat energy is converted to mechanical energy and finally to electricity. The entire process is only 40 percent efficient.

A fuel cell can do the same job—but much more efficiently! It converts the chemical energy in fuels **directly** into electrical energy. For this reason it is called an electrochemical device. These devices are being designed to run on many types of fuel, but the basic fuel cell runs on hydrogen and oxygen. A hydrogen/oxygen fuel cell is almost 100 percent efficient.

How It Works

A fuel cell works in much the same way as an ordinary dry cell or storage battery. It has two electrodes joined by an electrolyte, a substance which conducts electricity. A chemical reaction in the cell produces an electric current in an external circuit. But unlike a storage battery, fuel cells do not contain stored chemical energy. Instead, a fuel gas such as hydrogen is supplied to one electrode; air or oxygen is supplied to the other. In the cell, the hydrogen and oxygen combine to form water and release electrical energy in the process. As long as the fuel gases are fed to the electrodes, the fuel cell continues to operate.

The Advantages

Fuel cells can provide a clean, safe, convenient way of generating electricity. Because of their greater efficiency, they require less fuel to produce an equal amount of electricity than do conventional or nuclear power plants. They do not burn fuels, so they produce no air pollutants. And since they have no moving parts, they make no noise and are free of vibrations.

One big attraction of fuel cells is their flexibility. They can be built in large or small units depending on how much power is needed. A single cell produces only a small current. But many, many cells connected in series might produce enough power for an entire city.

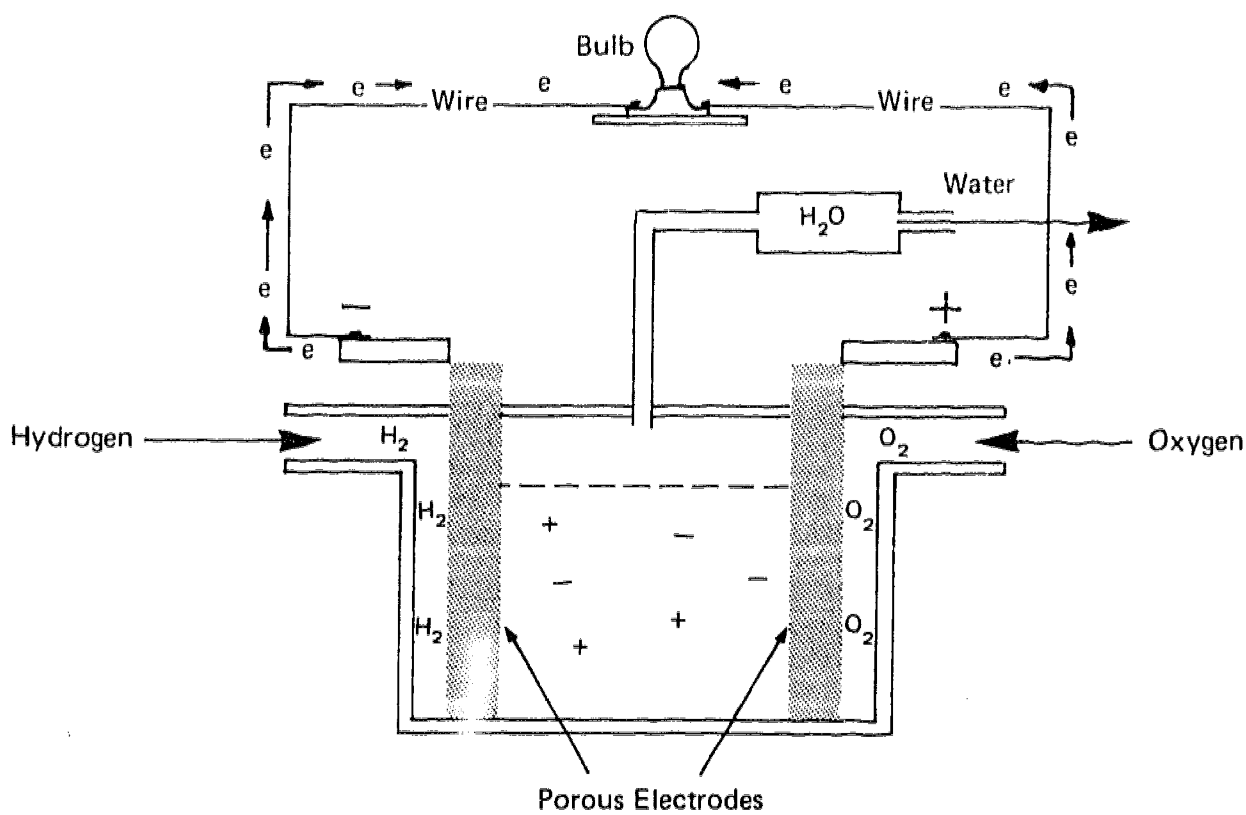
Fuel Cell Applications

In 1959, the first practical fuel cell was developed. It could power a forklift truck, a circular saw, or a welding device. NASA used hydrogen/oxygen fuel cells in the Gemini and Apollo missions because they were light in weight and took up very little space. The fuel cells were a source of electric power and of water. An experimental car using a combination of hydrogen/air fuel cells and ordinary storage batteries was built to go 200 miles without being refueled. It had a maximum speed of 50 miles per hour.

Many projects to develop new fuel-cell technology are now underway. In one project, coal is used to run a fuel-cell power plant. The coal is gasified to produce hydrogen which is then used to operate hydrogen/air fuel cells. Since this power system is 60 percent efficient, it produces one and one-half times more electrical energy from each ton of coal than a conventional plant produces.

The TARGET project is designing fuel-cell units to power individual homes. These units run on natural gas and air. They are only 45 percent efficient, but they avoid power losses from electrical transmission lines since electric power is produced right in the home.

Fuel-cell technology is still in its infancy. But one day, it may provide us with a clean, efficient, inexpensive way of generating electric power.



A FUEL CELL

SECTIONS OF THE UNIT	STUDENT RESOURCE BOOKLET	COMPONENTS TO COORDINATE WITH RESOURCE BOOKLET		
		Audio-Visual Materials	Ecomaster Activities	Extension Activities
The Energy Consumer	Preface to the Unit Foods, Fuels, and You	Filmstrip 1, Part A (Silent Filmstrip)	**Worksheet 1** Are You a Big Energy Consumer? **Worksheet 2** Energy in Action	**Activity Card 1** How Electric Is Your Home?
Problems of Supply and and Demand	**Blackout in the City!** **Conservation and Efficiency**	**Overhead Transparency** How Energy Use Has Changed **Overhead Transparency** Energy Use Grows in the U. S. **Overhead Transparency** Loss of Energy by Conversion	**Worksheet 3** The "Jeneration Jolt" **Worksheet 4** Blackout in the City! Can You Help? **Worksheet 5** Building a Generator **Worksheet 6** The Switch to Electric Power	**Activity Card 2** Appliances: Making a Wise Choice **Activity Card 3** Which Cars Use More Gasoline? **Activity Card 4** Incandescent vs. Fluorescent Lighting **Activity Card 5** Can the Roof of a House Save Energy? **Activity Card 6** Survey Your Home Insulation **Activity Card 7** Testing for Good Insulators **Activity Card 8** Designing a Turbine for Efficiency
Evaluation of Present Sources	**Our Present Sources** **The Oil Crisis** **The Nuclear Controversy**	**Filmstrip 1, Part B** Sources of Energy **Audio Cassette, Side A** **Overhead Transparency** How Does a Nuclear Reactor Work?		**Activity Card 9** Getting All the Oil Out
Evaluation of New Sources	**Tapping New Sources** **Developing Other Ways**	**Filmstrip 2** Sources of Energy **Audio Cassette, Side B**		**Activity Card 10** Is Wind a Good Source of Energy in Your Area? **Activity Card 11** Tapping Geothermal Energy **Activity Card 12** A Solar-powered Motor
Providing for the Future			**Worksheet 7** Congressional Hearing: The Energy Crisis **Worksheet 8** Providing for the Future	